UNIV. OF
TORONTO
LIBRARY

Mass Institute of Technology.
Society of Arts

INDEX SCIENCE CONSPECTUS VOL. II

	PAGE
Abbot, C. G., The Radiation of the Sun	134
Aeroplane, The Modern, Earle L. Ovington	125
Anticipating Business Conditions, Roger Babson	148
Architectural Acoustics, Lecture by Prof. Wallace C. Sabine	87
Arizona, The Small Cave Houses of, H. W. Shimer	16
Artificial Respiration, Creating	90
Austin Dam, The, L. E. Moore	6
Babson, Roger, Anticipating Business Conditions	148
Berry, Charles W., Tesla's Rotary Machine	7
Brownian Movement, The, D. F. Comstock	69
Cave Houses of Arizona, The Small, H. W. Shimer	16
Cherries, Adulteration in Maraschino, E. B. Spear	124
Civilization in Egypt, The Dawn of, Lecture by Prof. Geo. A. Reisner	72
Comstock, D. F., The Principles of Relativity, 13, 40; The Brownian Movement	69
The Light Quantity Hypothesis	115
Conservation and Research, H. T. Kalmus	152
Darwin, A Dissenter from, Lecture by Prof W. Johanssen	38
Dreams," Hints from "The World of Percy G. Stiles	54
Dual Water Supply	90
Efficiency in Public Health Work, Selskar M. Gunn	58
Egypt, The Dawn of Civilization in, Lecture by Prof. Geo. A. Reisner	72
Electrification, High Voltage, L. E. Moore	156
Electrification Problems, Solving, W. E. Wickenden	89
Emotion, The Physiology of, Percy G. Stiles	118
Food, Safeguarding Wholesome, A. G. Woodman	33
Food Preservatives, Spices as, Selskar M. Gunn	56
Fourth Dimension as a Text, E. B. Wilson	104
Gas, Poisoning by Illuminating, F. Schneider, Jr.	122
Geology of the Rhine Valley, H. W. Shimer	108
Gigantic Engineering Undertaking, Fred F. Moore	93
Gunn, Selskar M., Isolating the Typhoid Bacillus, 52; Spices as Food Preservatives, 56; Efficiency in Public Health Work	58
Heredity as an Experimental Science, C.-E. A. Winslow	1
High Voltage Electrification, L. E. Moore	156
Hints from "The World of Dreams," Percy G. Stiles	54
"Holes in the Air," L. E. Moore	57
Johanssen, J. Prof., Lecture by, A Dissenter from Darwin	38
Kalmus, H. T., Conservation and Research	152
Kuekenthal, Prof. W., Lecture by, Some New Facts About Whales	29
Light Quantity Hypothesis, The, D. E. Comstock	115
Liquid Crystals and Their Formation, Ellwood B. Spear	19
Lister, A Tribute to Lord, Lecture by Prof. Wm. T. Sedgwick	91
Loughlin, G. F., Potash Sources in the United States	45
Maraschino Cherries, Adulteration in, E. B. Spear	124
Mercury Vapor Lamp, Improving the, L. E. Moore	92
Milk Supply of Boston, The, Samuel C. Prescott	22
Modern Aeroplane, The, Earle L. Ovington	125
Monsters and Their Production, Charles R. Stockard	61
Moore, Fred F., A Gigantic Engineering Undertaking	93
Moore, L. E., The Austin Dam, 6; Storage Battery Electrification, 55; "Holes in the Air," 56; The Boston Subway, 78; Improving the Mercury Vapor Lamp, 92; A Remarkable Ore-Handling Dock, 120; High Voltage Electrification	156
New Members of the Society	39, 86, 121
Norton, John F., Ventilation of Sleeping Cars	79
Ore-Handling Dock, A Remarkable, L. E. Moore	120

136 3
14/5

PAGE

Ovington, Earle L., The Modern Aeroplane . . . 125
Ozone in Brewing, The Use of, F. Schneider, Jr. 147
Pasteur Institute, Science Fighting Against Disease 83
Physiology of Emotion, The, Percy G. Stiles . . 118
Potash Sources in the United States, G. F. Loughlin 45
Prescott, Samuel C., The Milk Supply of Boston 22
Principles of Relativity, The, D. F. Comstock 13, 40
Prolonging Life by Thorium, E. B. Spear 86
Public Health Work, Efficiency in, Selskar M. Gunn 58
Radiation of the Sun, The, C. G. Abbot 134
Reisner, Prof. Geo. A., Lecture, The Dawn of Civilization in Egypt 72
Relativity, The Principles of, D. F. Comstock 13, 40
Rhine Valley, Geology of The, H. W. Shimer 108
Sabine, Wallace C., Lecture, Architectural Acoustics 87
Safeguarding Wholesome Food, A. G. Woodman 33
Schneider, F., Jr., Structural Strength of Plants, 92; Vegetables and Typhoid Fever, 119; Poisoning by Illuminating Gas, 123; Ringworm, 124; The Use of Ozone in Brewing 147
Science Fighting Against Disease 83
Sedgwick, William T., Lecture by; A Tribute to Lord Lister 91
Shimer, H. W., The Small Cave Houses of Arizona, 16; Geology of the Rhine Valley 108
Sleeping Cars, Ventilation of, John F. Norton 79

PAGE

Spear, Ellwood B., Liquid Crystals and Their Formation, 19; Prolonging Life by Thorium, 86; Adulteration in Maraschino Cherries . . . 124
Spices as Food Preservatives, Selskar M. Gunn 56
Stiles, Percy G., Hints from "The World of Dreams," 54; the Physiology of Emotion . . . 118
Stockard, Charles R., Monsters and Their Production 61
Storage Battery Electrification, Lewis E. Moore 55
Structural Strength of Plants, F. Schneider, Jr. 92
Subway, The Boston, L. E. Moore 78
Tesla's Rotary Machine, Charles W. Berry . . . 7
Thorium, Prolonging Life by, E. B Spear 86
Tribute to Lord Lister, a lecture. by W. T. Sedgwick 91
Typhoid Bacillus, Isolating the, Selskar M. Gunn 52
Typhoid Fever, Vegetables and, F. Schneider, Jr. 119
Use of Ozone in Brewing, The, F. Schneider, Jr. 147
Ventilation of Sleeping Cars, John F. Norton 79
Water Supply of New York, F. F. Moore 93
Whales, Some New Facts About, Lecture by Prof. W. Kuekenthal 29
Wickenden, W. E., Solving Electrification Problems 89
Wilson, E. B., The Fourth Dimension as a Text 104
Winslow, C.-E. A., Heredity as an Experimental Science 1
Woodman, A. G., Safeguarding Wholesome Food 33

OFFICERS OF THE SOCIETY OF ARTS 1911–1912

President of the Institute
RICHARD C. MACLAURIN

Secretary of the Society of Arts
ISAAC W. LITCHFIELD

Executive Committee

ELIHU THOMSON
JAMES P. MUNROE
THE PRESIDENT
THEODORE N. VAIL
CARROLL W. DOTEN
FREDERIC H. FAY
THE SECRETARY

LIST OF MEMBERS

Members are requested to inform the secretary of any change of address

THE CORPORATION

LIFE MEMBERS

Bowditch, Ernest W. . . . . 62 Devonshire Street, Boston, Mass.
*Carson, Howard A. . . . . 79 Glenwood Street, Malden, Mass.
Crane, W. Murray . . . . . Dalton, Mass.
Draper, Eben S. . . . . Hopedale, Mass.
du Pont, T. Coleman . . . . . Wilmington, Del.
**Endicott, William . . . . . 32 Beacon Street, Boston, Mass.
Estabrook, Arthur F. . . . . 15 State Street, Boston, Mass.
Felton, Samuel M. . . . . 1366 Dearborn Avenue, Chicago, Ill.
Fish, Frederick P. . . . . 84 State Street, Boston, Mass.
*FitzGerald, Desmond . . . . . 408 Washington Street, Brookline, Mass.
*Freeman, John R. . . . . 815 Banigan Building, Providence, R. I.
*Hart, Francis R. . . . . Milton, Mass.
Higginson, Francis L. . . . . 274 Beacon Street, Boston, Mass.
*Hubbard, Charles W. . . . . 514 Shawmut Bank Building, Boston, Mass.
*Jackson, Charles C. . . . . 19 Congress Street, Boston, Mass.
Lee, Elliot Cabot . . . . . Brookline, Mass.
Lincoln, William H. . . . . 1151 Tremont Building, Boston, Mass.
Livermore, Thomas L. . . . . 14 Ashburton Place, Boston, Mass.
Longyear, John M. . . . . Leicester Street, Brookline, Mass.
*Lowell, A. Lawrence . . . . . Harvard University, Cambridge, Mass.
*Lowell, Percival . . . . . 53 State Street, Boston, Mass.
Mills, Hiram F. . . . . 266 Andover Street, Lowell, Mass.
*Munroe, James P. . . . . 79 Summer Street, Boston, Mass.
Peabody, Robert S. . . . . 22 The Fenway, Boston, Mass.
*Putnam, William Lowell . . . . . 60 State Street, Boston, Mass.
*Rotch, A. Lawrence . . . . . 1124 Board of Trade Building, Boston, Mass.
*Sewall, J. B. . . . . 1501 Beacon Street, Brookline, Mass.
Stearns, James P. . . . . National Shawmut Bank, Boston, Mass.
Stockton, Howard . . . . . 50 State Street, Boston, Mass.
*Stone, Charles A. . . . . 147 Milk Street, Boston, Mass.
*Thomson, Elihu . . . . . 42 Centre Street, West Lynn, Mass.
Thurber, William B. . . . . Milton, Mass.
*Tolman, James P. . . . . 88 Broad Street, Boston, Mass.
Lucius Tuttle . . . . . 1120 Beacon Street, Brookline, Mass.
*Wigglesworth, George . . . . . 53 State Street, Boston, Mass.
*Williams, Francis H. . . . . 505 Beacon Street, Boston, Mass.

*Associate member, Society of Arts.
**Life member, Society of Arts.

Term Members

Term expires March, 1912

Hale, George E. . . . . Solar Observatory Office, Pasadena, Cal.
Kittredge, George W. . . . . Grand Central Station, New York, N. Y.
*Stantial, Frank G. . . . . Cochrane Chemical Co., Everett, Mass.

Term expires March, 1913

Rollins, James W., Jr. . . . . 922 Beacon Building, Boston, Mass.
*Morss, Everett . . . . . 201 Devonshire Street, Boston, Mass.
*Bradlee, Arthur T. . . . . 78 Chauncy Street, Boston, Mass.

Term expires March, 1914

Richards, Charles R. . . . . Cooper Union, New York, N. Y.
Snow, Walter B. . . . . 170 Summer Street, Boston, Mass.
Robinson, Theodore W. . 1524 Commercial National Bank Building, Chicago, Ill.

Term expires March, 1915

Cunningham, Edward . . . . . 141 Milk Street, Boston, Mass.
Rollins, Frank W. . . . . John Hancock Building, Boston, Mass.
*Webster, Edwin S. . . . . P. O. Box 5304. Boston, Mass.

Term expires March, 1916

Howard, Henry . . . . . 36 Amory Street, Longwood, Mass.
*Morss, Henry A. . . . . 463 Commonwealth Avenue, Boston, Mass.
*Winslow, Arthur . . . . . 131 State Street, Boston, Mass.

On the Part of the Commonwealth

His Excellency the Governor
The Honorable the Chief Justice of the Supreme Court
The Honorable the Commissioner of Education

LIFE MEMBERS

Addicks, J. Edward . . . . . 1106 King Street, Wilmington, Del.
Beal, James H. . . . . 104 Beacon Street, Boston, Mass.
Breed, Francis W. . . . . 45 Dana Street, Cambridge, Mass.
Coffin, F. S. . . . . 433 Walnut Street, Brookline, Mass.
Endicott, William . . . . . 32 Beacon Street, Boston, Mass.
Griffin, Eugene . . . . . 44 Broad Street, New York, N. Y.
Hewins, Edmund H. . . . . 201 Devonshire Street, Boston, Mass.
Little, James L. . . . . Goddard Avenue, Brookline, Mass.
Little, John M. . . . . 317 Dartmouth Street, Boston, Mass.
Moore, Alexander . . . . . 11 Hamilton Place, Boston, Mass.
Parker, Walter E. . . . . Agent, Pacific Mills, Lawrence, Mass.
Pickering, E. C. . . . . Harvard College Observatory, Cambridge, Mass.
Rollins, William H. . . . . 250 Marlborough Street, Boston, Mass.
Sawyer, Edward . . . . . Newton, Mass.
Sayles, Henry . . . . . 56 Commonwealth Avenue, Boston, Mass.
Sherwin, Thomas . . . . . Revere Street, Jamaica Plain, Mass.
Shurtleff, A. M. . . . . 9 West Cedar Street, Boston, Mass.
Tufts, John W. . . . . Camden, Me.
Ware, William R. . . . . Milton, Mass.
Watson, William . . . . . 107 Marlborough Street, Boston, Mass.
Whitaker, Channing . . . . . Lowell, Mass.
Willcutt, Levi W. . . . . Post Office Box 5239, Boston, Mass.
Wing, Charles H. . . . . 92 Brooks Street, Brighton, Mass.
Woodbury, C. J. H. . . . . 45 Milk Street, Boston, Mass.

ASSOCIATE MEMBERS

Alden, John . . . . . Lawrence, Mass.
Allen, C. Frank . . . . . Mass. Institute of Technology, Boston, Mass.
Allen, Mrs. Thomas . . . . . 12 Commonwealth Avenue, Boston, Mass.
Allyn, Robert S. . . . . 16 Exchange Place, New York, N. Y.
Almy, Charles, Jr. . . . . 147 Brattle Street, Cambridge, Mass.
Amster, N. L. . . . . 6 Hawes Street, Brookline, Mass.
Andrews, Clement W. . . . . John Crerar Library, Chicago, Ill.
Appleton, Charles B. . . . . Netherlands Road, Brookline, Mass.
Arms, John T., Jr. . . . . 3 Spruce Street, Boston, Mass.
Armstrong, O. S. . . . . Riverside Press, Cambridge, Mass.
Atwood, Frank W. . . . . 216 Milk Street, Boston, Mass.
Bancroft, C. F. . . . . 84 State Street, Boston, Mass.
Barbour, Edmund D. . . . . 610 Sears Building, Boston, Mass.
Bardwell, F. L. . . . . Case School of Applied Science, Cleveland, Ohio.
Barnes, Herbert H. . . . . Hotel Brunswick, Boston, Mass.
Barron, C. W. . . . . 21 Exchange Place, Boston, Mass.
Barry, John L., Jr. . . . . 179 South Street, Boston, Mass.
Barstow, George E. . . . . 56 Graves Avenue, Lynn, Mass.
Bartlett, Dana P. . . . . Mass. Institute of Techology, Boston, Mass.
Bartlett, Francis . . . . . 40 State Street, Boston, Mass.
Bartlett, Spaulding . . . . . Webster, Mass.
Bartow, Stephen E. . . . . 4 Liberty Square, Boston, Mass.
Bassett, William H. . . . . 146 Litchfield Street, Torrington, Conn.
Batcheller, Henry R. . . . . Box 21, Washington, N. H.
Batcheller, Robert . . . . . 723 15th Street, N. W., Washington, D. C.
Baxter, Sylvester . . . . . 32 Murray Hill Road, Malden, Mass.
Beasom, C. B. . . . . 248 Tremont Street, Newton, Mass.
Bemis, A. F. . . . . 89 State Street, Boston, Mass.
Bennett, Henry D. . . . . 85 Water Street, Boston, Mass.
Benson, Edward M. . . . . 101 Milk Street, Boston, Mass.
Bigelow, Homer L. . . . . Old Orchard Road, Chestnut Hill, Mass.
Bigelow, Robert P. . . . . Mass. Institute of Technology, Boston, Mass.
Binney, Amos . . . . . 526 Exchange Building, Boston, Mass.
Blake, Mrs. Arthur W. . . . . 450 Washington Street, Brookline, Mass.
Blake, Francis . . . . . Auburndale, Mass.
Blood, William H., Jr. . . . . 147 Milk Street, Boston, Mass.
Boit, Robert A. . . . . 40 Kilby Street, Boston, Mass.
Brackett, Dexter . . . . . 712 Washington Street, Brighton, Mass.
Bradlee, Arthur T. . . . . Chestnut Hill, Mass.
Braley, Samuel T. . . . . Rutland, Vt.
Brewer, Edward M. . . . . 40 Churchill Lane, Milton, Mass.
Brophy, William . . . . . 17 Egleston Street, Jamaica Plain, Mass.
Brown, C. Leonard . . . . . 38 Wallace Street, W. Somerville, Mass.
Brown, Dickson Q. . . . . 11 Broadway, New York, N. Y.
Brown, Samuel N. . . . . 119 Commonwealth Avenue, Boston, Mass.
Brown, Walter S. . . . . Underhill Center, Vt.
Bryden, George W. . . . . 47 Prospect Street, Winthrop, Mass.
Burns, Peter S. . . . . Milton, Mass.
Cameron, J. A. . . . . Forge Village, Mass.
Carruth, Charles T. . . . . 4 Fayerweather Street, Cambridge, Mass.
Carson, Howard A. . . . . 79 Glenwood St., Malden, Mass.
Carty, John J. . . . . 15 Dey Street, New York, N. Y.
Chandler, F. W. . . . . 195 Marlborough Street, Boston, Mass.
Chase, F. D. . . . . Smelter No. 2, Monterey, Mexico.
Claflin, George E. . . . . 47 Ames Building, Boston, Mass.
Clapp, George A. . . . . 49 Federal Street, Boston, Mass.
Clark, Myron H. . . . . 7 Glen Rock Circle, Malden, Mass.

Clarke, Alfred	131 State Street, Boston, Mass.
Clarke, Ralph S.	35 Rockwell Street, Dorchester Center, Mass.
Clifford, H. E.	Harvard University, Cambridge, Mass.
Coburn, Howard L.	83 Newbury Street, Boston, Mass.
Codman, J. S.	93 Broad Street, Boston, Mass.
Coffin, C. A.	145 West 58th Street, New York, N. Y.
Cole, L. L.	32 Franklin Street, Boston, Mass.
Collins, R. B.	21 Elam Place, Buffalo, N. Y.
Colson, Warren H.	184 Boylston Street, Boston, Mass.
Colt, James D.	53 State Street, Boston, Mass.
Cook, Thomas N.	189 Congress Street, Boston, Mass.
Copeland, William A.	365 Hammond Street, Chestnut Hill, Mass.
Crafts, J. Chancellor	77 Lanark Road, Brookline, Mass.
Crafts, James M.	111 Commonwealth Avenue, Boston, Mass.
Cress, Leonidas H.	Brae Burn Country Club, West Newton, Mass.
Crosby, William O.	9 Park Lane, Jamaica Plain, Mass.
Crosby, William W.	53 State Street, Boston, Mass.
Cross, C. R.	Mass. Institute of Technology, Boston, Mass.
Currier, Guy W.	84 State Street, Boston, Mass.
Curtis, Henry P.	The Lenox, Boston, Mass.
Cutter, Louis F.	33 Chestnut Street, Salem, Mass.
Dabney, Herbert	45 Broad Street, Boston, Mass.
Dana, Gorham	17 Edge Hill Road, Brookline, Mass.
Davis, Edmund S.	15 Beacon Street, Boston, Mass.
Davis, Edward W.	152 Purchase Street, Boston, Mass.
Davis, Nelson C., M. D.	Care of H. P. Hood & Sons, Charlestown, Mass.
Day, Frank A.	35 Congress Street, Boston, Mass.
Day, Nathan B.	280 Newbury Street, Boston, Mass.
Defren, George	9 Fairbanks Street, Brookline, Mass.
Densmore, Edward D.	26 Downing Road, Brookline, Mass.
Dodd, John W.	3 Auburn Court, Brookline, Mass.
Dodge, Chester P.	Rockport, Mass.
Doliber, Thomas	291 Atlantic Avenue ,Boston, Mass.
Doten, Carroll W.	Mass. Institute of Tecnology, Boston, Mass.
Douglas, Robert	166 Essex Street, Boston, Mass.
Dudley, P. H.	Grand Central Station, New York, N. Y.
Dunbar, W. O.	1218 13th Street, Altoona, Pa.
Emerson, Guy C.	4 Brewer Street, Jamaica Plain, Mass.
Emery, Ralph C.	114 State Street, Boston, Mass.
Eustis, J. P.	Ames Street, Cambridge, Mass.
Eustis, W. E. C.	131 State Street, Boston, Mass.
Eynon, John S.	20 Kilby Street, Boston, Mass.
Farrington, Charles E.	200 Summer Street, Boston, Mass.
Fay, Frederic H.	60 City Hall, Boston, Mass.
Fish, Charles H.	Garner Print Works & Bleachery, Wappingers Falls, N. Y.
FitzGerald, Desmond	Brookline, Mass.
FitzGerald, Francis A. J.	Post Office Box 118, Niagara Falls, N. Y.
Flather, Frederick A.	68 Mansur Street, Lowell, Mass.
Fobes, Edwin F.	3 Chandler Street, Lexington, Mass.
Foss, E. N.	11 Revere Street, Jamaica Plain, Mass.
Fox, Charles K.	Haverhill, Mass.
Freeman, John R.	815 Banigan Building, Providence, R. I.
French, E. V.	31 Milk Street, Boston, Mass.
Fuller, Charles E.	Mass. Institute of Technology, Boston, Mass.
Fuller, George W.	170 Broadway, New York, N. Y.
Gallagher, H. C.	45 Broad Street, Boston, Mass.
Garfield, A. S.	10 rue de Londres, Paris, France.
Gill, Augustus H.	Mass. Institute of Technology, Boston, Mass.
Gilley, Frank M.	21 John Street, Chelsea, Mass.
Gilman, Wesley C.	31 Exchange Street, Lynn, Mass.

Gleason, Gilbert H. . . . . 146 Jewett Street, Newton, Mass.
Goodell, George H., Care Rank & Goodell, Pioneer Press Building, St. Paul, Minn.
Goodspeed, Joseph H. . . . . 279 Newbury Street, Boston, Mass.
Gray, Joseph P. . . . . Box 112, Boston, Mass.
Greenleaf, Lewis S. . . . . Care Hudson River Telephone Co., Albany, N. Y.
Grover, Nathan C. . . . . 1330 F Street, N. W., Washington, D. C.
Gyzander, C. R. . . . . Cochrane Chemical Co., Everett, Mass.
Hale, Richard A. . . . . Lawrence, Mass.
Hamblet, George W. . . . . 506 Lowell Street, Lawrence, Mass.
Hamilton, George Wyman . . . . . 30 Tremont Street, Boston, Mass.
Hart, Francis R. . . . . Milton, Mass.
Hawkins, Edgar M. . . . . 100 Park Avenue, Rochester, N. Y.
Hayes, Hammond V. . . . . 101 Milk Street, Boston, Mass.
Hazen, Allen . . . . . 103 Park Avenue, New York, N. Y.
Henderson, Charles W., Jr. . . . . 374 Congress Street, Boston, Mass.
Henderson, F. C. . . . . 263 Clinton Road, Brookline, Mass.
Herrick, Rufus F. . . . . 22 Herrick Street, Winchester, Mass.
Hill, William H. . . . . 50 Congress Street, Boston, Mass.
Hobart, John D. . . . . Malden, Mass.
Hobbs, Franklin W. . . . . Brookline, Mass.
Hodgdon, Frank W. . . . . 18 Wellington Street, Arlington, Mass.
Hofman, H. O. . . . . Mass. Institute of Technology, Boston, Mass.
Hollis, Frederick S. . . . . 640 Middle Drive, Indianapolis, Ind.
Holman, G. M. . . . . 52 Pleasant Street, Fitchburg, Mass.
Holst, E. W. . . . . Post Office Box 2072, Boston, Mass.
Holton, Edward C. . . . . 104 Canal Street, Cleveland, Ohio.
Holtzer, Charles W. . . . . Brookline, Mass.
Hopewell, Charles F. . . . . 42 Osborne Street, Cambridge, Mass.
Hopkins, Woodworth . . . . . 123 Westmorley Court, Cambridge, Mass.
Horton, Theodore . . . . . State Department of Health, Albany, N. Y.
Howe, Henry M. . . . . Bedford Station, New York, N. Y.
Hubbard, Charles W. . . . . 55 Congress Street, Boston, Mass.
Humphrey, S. K. . . . . 83 Newbury Street, Boston, Mass.
Hunneman, W. C. . . . . 94 Colchester Street, Brookline, Mass.
Hunsaker, Jerome C. . . . . 1677 Beacon Street, Brookline, Mass.
Huse, Frank J. . . . . 2624 Thayer Street, Evanston, Ill.
Jackson, Charles C. . . . . 19 Congress Street, Boston, Mass.
Jackson, Dugald C. . . . . Mass. Institute of Technology, Boston, Mass.
Jackson, Henry D. . . . . 88 Broad Street, Boston, Mass.
James, Frank M. . . . . 518 West 145th Street, New York, N. Y.
Jenks, William J. . . . . Room 1923 30 Church Street, New York, N. Y.
Johnson, Henry L. . . . . 337 Metopolitan Avenue, Roslindale, Mass.
Johnson, Jesse F. . . . . 6 Grosvenor Apts., Montreal, Can.
Johnson, William S. . . . . 101 Tremont Street, Boston, Mass.
Jones, Jerome . . . . . 33 Franklin Street, Boston, Mass.
Jones, J. Edwin. . . . . 86 Rock View Street, Jamaica Plain, Mass.
Jones, Milton F. . . . . 71 Kilby Street, Boston, Mass.
Keith, Simeon C., Jr. . . . . 394 Rutherford Avenue, Charlestown, Mass.
Keller, Carl Tilden . . . . . 119 Milk Street, Boston, Mass.
Kimball, Frank W. . . . . 283 Walnut Street, Dedham, Mass.
Kimball, Fred M. . . . . 49 Elmhurst Road, Newton, Mass.
Kimball, Joseph H. . . . . 620 Equitable Building, Louisville, Ky.
Knight, A. S. . . . . 309 Sears Building, Boston, Mass.
Knights, Arthur A. . . . . 100 Beacon Street, Worcester, Mass.
Knowles, Morris . . . . . Filtration Bureau, City Hall, Pittsburg, Pa.
Lanza, Gaetano. . . . . The Montevista, 63d & Oxford Sts., Overbrook, Pa.
Lawrence, Ralph R. . . . . Mass. Institute of Tecnology, Boston, Mass.
Lawrence, William H. . . . . Mass. Institute of Technology, Boston, Mass.
Laws, Frank A. . . . . Mass. Institute of Technology, Boston, Mass.
Learned, Isaac N. . . . . 674½ Tremont Street, Boston, Mass.

Leavitt, E. D. . . . . 33 Garden Street, Cambridge, Mass.
Lee, John C. . . . . Longwood, Mass.
Leland, Walter S. San Francisco Bridge Co., Monadnock Bldg., San Francisco, Cal.
Leverett, George V. . . . . 66 Beacon Street, Boston, Mass.
Lincoln, Miss A. W. . . . . Lincoln Road, Medford, Mass.
Lincoln, E. S. . . . . 132 Summit Avenue, Brookline, Mass.
Litchfield, Isaac W. . . . . Mass. Institute of Technology, Boston, Mass.
Little, A. D. . . . . 93 Broad Street, Boston, Mass.
Lockett, Kenneth . . . . . 5116 Madison Avenue, Chicago, Ill.
Lodge, H. Ellerton . . . . . Post Office Box 2228, Boston, Mass.
Lodge, Richard W. . . . . P. O. Box 84, Redlands, Cal.
Longley, Edmund W. . . . . 318 Lafayette Street, Salem, Mass.
Lonngren, John E. . . . . Supt. Wire Mills, Cambria Steel Co., Johnstown, Pa.
Lord, Charles E. . . . . 24 Milk Street, Boston, Mass.
Loring, Lindsey . . . . . Fox Hill Street, Westwood, Mass.
Loud, Joseph P. . . . . 85 Water Street, Boston, Mass.
Lovell, Fred W. . . . . 69 Mt. Vernon Street, North Cambridge, Mass.
Lowe, A. W. . . . . 1 Olive Street, Lynn, Mass.
Lowell, A. Lawrence . . . . . Harvard University, Cambridge, Mass.
Lowell, James A. . . . . Chestnut Hill, Mass.
Lowell, Percival . . . . . 53 State Street, Boston, Mass.
Lyman, Arthur T. . . . . P. O. Box 1717, Boston, Mass.
Lythgoe, Hermann C. . . . . Room 501, State House, Boston, Mass.
McCarter, F. W. . . . . 17 Lewis Wharf, Boston, Mass.
McClench, William W. . . . . Springfield, Mass.
McJunkin, Paul . . . . . 201 East 16th Street, New York, N. Y.
Main, Charles T. . . . . 201 Devonshire Street, Boston, Mass.
Martin, Henry . . . . . 23 Davenport Street, Lowell, Mass.
Mellen, Edwin D. . . . . 1590 Massachusetts Avenue, Cambridge, Mass.
Melluish, James G. . . . . 222 Unity Building, Bloomington, Ill.
Merrill, S. M. . . . . 120 Boylston Street, Boston, Mass.
Metcalf, Leonard . . . . . 14 Beacon Street, Boston, Mass.
Miles, George W. . . . . 29 Central Street, Boston, Mass.
Mills, Harrison W. . . . . 7 Produce Exchange, Boston, Mass.
Minns, Miss Susan . . . . . 14 Louisburg Square, Boston, Mass.
Moody, Frederick C. . . . Kansas & Missouri Telephone Co., Kansas City, Mo.
Moore, Fred F. . . . . P. O. Box 81, Hawthorn, N. Y.
Morss, Everett . . . . . 201 Devonshire Street, Boston, Mass.
Morss, Henry A. . . . . 463 Commonwealth Avenue, Boston, Mass.
Morss, John Wells . . . . . 201 Devonshire Street, Boston, Mass.
Mosman, Philip A. . . . . 165 Broadway, New York, N. Y.
Mulliken, Samuel P. . . . . Mass. Institute of Technology, Boston, Mass.
Munroe, James P. . . . . Room 62, 79 Summer Street, Boston, Mass.
Musolino, A . . . . . Wilmington, Mass.
Neall, N. J. . . . . 12 Pearl Street, Boston, Mass.
Newcomb, G. . . . . 15 Ward Street, Salem, Mass.
Norris, Albert P. . . . . 760 Massachusetts Avenue, Cambridge, Mass.
North, Isaac F. . . . . 70 Montvale Road, Newton Centre, Mass.
Northey, Edward A. . . . . 70 Kilby Street, Boston, Mass.
Norton, Edward E. . . . . 105 Chauncy Street, Boston, Mass.
Noyes, Arthur A. . . . . Mass. Institute of Technology, Boston, Mass.
Nutter, H. G. . . . . Court House, Chelsea, Mass.
Nutter, R. H. . . . . Post Office Box 272, Lynn, Mass.
Nutting, George H. . . . . 119 Aldrich Street, Boston, Mass.
O'Connell, P. A. . . . . 155 Tremont Street, Boston, Mass.
Ohlson, Olof . . . . . 472 Crafts Streets, West Newton, Mass.
Osborne, George A. . . . . Mass. Institute of Technology, Boston, Mass.
Paine, William A. . . . . 82 Devonshire Street, Boston, Mass.
Parker, Horatio N. . . . . 2426 St. Paul Street, Baltimore, Md.
Patterson, George W., Jr. . . . 14 South University Avenue, Ann Arbor, Mich.

Peabody, C. H. . . . . Mass. Institute of Technology, Boston, Mass.
Phillips, A. V. . . . . 89 State Street, Boston, Mass.
Pickert, Leo W. . . . . 16 New Street, East Boston, Mass.
Pollock, Clarence D. . . . . 531 East 23d Street, Brooklyn, N. Y.
Pope, T. E. . . . . Mass. Institute of Technology, Boston, Mass.
Porter, Dwight . . . . . Mass. Institute of Technology, Boston, Mass.
Pratt, Herbert G. . . . . 56 Bellevue Street, Newton, Mass.
Prescott, Samuel C. . . . . Mass. Institute of Technology, Boston, Mass.
Putnam, William Lowell . . . . . 49 Beacon Street, Boston, Mass.
Quimby, C. N. . . . . 60 Hillside Avenue, Arlington Heights, Mass.
Raeburn, Andrew . . . . . Room 47, 70 Kilby Street, Boston, Mass.
Reardon, T. F. E. . . . . Hotel Longfellow, West Lynn, Mass.
Reynolds, Howard, S. . . . . Ludlow Mgf. Co., Ludlow, Mass.
Rich, Isaac. . . . . 36 Walnut Street, Somerville, Mass.
Richards, Miss Alice A. . . . . 98 Cochester Street, Brookline, Mass.
Richards, R. H. . . . . Mass. Institute of Technology, Boston, Mass.
Roberts, George L. . . . . 95 Milk Street, Boston, Mass.
Robinson, Edward P. . . . . 80 Border St., E. Boston, Mass.
Rogers, Miss Annette P. . . . . 5 Joy Street, Boston, Mass.
Rolfe, George W. . . . . Mass. Intsitute of Technology, Boston, Mass.
Rotch, A. Lawrence . . . . . 1124 Board of Trade Building, State Street, Boston, Mass.
Royce, Frederick P. . . . . Common Street, Dedham, Mass.
Sanborn, Frank E. . . . . Ohio State University, Columbus, Ohio.
Sando, Will J. . . . . Allis-Chalmers Co., Milwaukee, Wis.
Sauveur, Albert . . . . . Hatch Building, Cambridge, Mass.
Sawtelle, William O. . . . . 4 Mercer Circle, Cambridge, Mass.
Sawyer, Albert H. . . . . 19 Pearl Street, Boston, Mass.
Sawyer, Alfred H. . . . . 237 West Newton Street, Boston, Mass.
Schonler, James . . . . . 2 Newbury Street, Boston, Mass.
Schrafft, William E. . . . . 16 Charlestown Bridge, Boston, Mass.
Schwamb, Peter . . . . . Mass. Institute of Technology, Boston, Mass.
Sears, Horace S. . . . . Weston, Mass.
Sears, Russell A. . . . . 101 Milk Street, Boston, Mass.
Sewall, J. B. . . . . 1051 Beacon Street, Brookline, Mass.
Shattuck, A. Forrest . . . . . The Solvay Process Co., Detroit, Mich.
Shaw, Henry S. . . . . Milton, Mass.
Sherman, George W. . . . . Akron, Ohio.
Shuman, A. . . . . 440 Washington Street, Boston, Mass.
Shute, George P. . . . . 1091 South High Street, Columbus, Ohio.
Slater, H. C. . . . . Post Office Box 102, Ridley Park, Pa.
Smith, Harrison W. . . . . Mass. Institute of Technology, Boston, Mass.
Smith, Hubert S. . . . . 215 Newbury Street, Boston, Mass.
Smith, John W. . . . . 7 Brookfield Street, Roslindale, Mass.
Snow, F. Herbert . . . . . State Department of Health, Harrisburg, Pa.
Snyder, Frederic S. . . . . 55 Blackstone Street, Boston, Mass.
Sohier, William D. . . . . 79 Beacon Street, Boston, Mass.
Solomont, James . . . . . 41 Georgia Street, Roxbury, Mass.
Spear, Walter E. . . . . 250 West 54th Street, New York, N. Y.
Spinney, Frank C. . . . . 636 Beacon Street, Boston, Mass.
Sprague, Isaac . . . . . P. O. Box 3134, Boston, Mass.
Stantial, F. G. . . . . Care Cochrane Chemical Co., Everett, Mass.
Stearns, Frederic P. . . . . 1 Ashburton Place, Boston, Mass.
Stearns, F. W. . . . . 269 Park Street, Newton, Mass.
Stevens, Walter F. . . . . 1190 Boylston Street, Newton Upper Falls, Mass.
Stoddard, George H. . . . . 133 Commercial Street, Boston, Mass.
Stone, Charles A. . . . . Post Office Box 5304, Boston, Mass.
Stone, John S. . . . . 192 Bay State Road, Boston, Mass.
Sullivan, P. F. . . . . 84 State Street, Boston, Mass.
Sully, John M. . . . . Chino Copper Co., Santa Rita, N. M.
Sumner, John O. . . . . Mass. Institute of Technology, Boston, Mass.

Suter, Russell . . . . . State Water Supply Commission, Albany, N. Y.
Swain, George F. . . . . Harvard University, Cambridge, Mass.
Sweet, H. N. . . . . 63 Mt. Vernon Street, Boston, Mass.
Talbot, Henry P. . . . . Mass. Institute of Technology, Boston, Mass.
Taylor, R. R. . . . . Tuskegee Institute, Tuskegee, Ala.
Thomson, Elihu . . . . . 42 Centre Street, West Lynn, Mass.
Thorp, Frank H. . . . . Mass. Institute of Technology, Boston, Mass.
Thorpe, Gardner E. . . . . P. O. Box 33, Boston, Mass.
Tillinghast, Charles F. . . . . 260 Angell Street, Providence, R. I.
Tinkham, S. Everett . . . . . 65 City Hall, Boston, Mass.
Tolman, James P. . . . . 88 Broad Street, Boston, Mass.
Traiser, Charles H. . . . . 530 Beacon Street, Boston, Mass.
Travis, George C. . . . . 101 Milk Street, Boston, Mass.
Tripp, Thaxter N. . . . . 11 Baltimore Street, Lynn, Mass.
Tucker, G. R. . . . . 68 Northampton Street, Boston, Mass.
Turner, E. K. . . . . 53 State Street, Boston, Mass.
Turner, Everett P. . . . . Arlington, Mass.
Turner, Howard C. . . . . 386 Commonwealth Avenue, Boston, Mass.
Tyler, Harry W. . . . . Mass. Institute of Technology, Boston, Mass.
Underwood, George R. . . . . Peabody, Mass.
Underwood, W. Lyman . . . . . Belmont, Mass.
Vail, Theodore N. . . . . 125 Milk Street, Boston, Mass.
Vaillant, George W. . . . . 53 State Street, Boston, Mass.
Van Nostrand, A. G. . . . . 482 Beacon Street, Boston, Mass.
Vesper, Robert A. . . . . 89 Waldeck Street, Dorchester Center, Mass.
Wachter, Carl . . . . . 390 Harvard Street, Cambridge, Mass.
Wadleigh, Horace W. . . . . 234 Commonwealth Avenue, Boston, Mass.
Walker, Charles R. . . . . 47 Wendell Street, Cambridge, Mass.
Walker, John B. . . . . 70 State Street, Boston, Mass.
Walker, William H. . . . . Mass. Institute of Technology, Boston, Mass.
Ware, Horace E. . . . . 110 Summer Street, Boston, Mass.
Warren, Henry E. . . . . The Lombard Governor Co., Ashland, Mass.
Washburn, Thomas G. . . . . 68 Pemberton Square, Boston, Mass.
Wason, Leonard C. . . . . 1 Summit Avenue, Brookline, Mass.
Webster, David L. . . . . 134 Summer Street, Boston, Mass.
Webster, Edwin S. . . . . Box 5304, Boston, Mass.
Wells, Webster . . . . . The Beaconsfield, Brookline, Mass.
Wesson, Paul B. . . . . Lowell Machine Shop, Lowell, Mass.
Weston, David B. . . . . Sharon, Mass.
Wheelright, Henry M. . . . . Union Street, Ware, Mass.
Whipple, George C. . . . . 103 Park Avenue, New York, N. Y.
Whitman, William . . . . . Box 100, Essex Street Station, Boston, Mass.
Whitney, Hammond M. . . . . 39 Carleton Street, Brookline, Mass.
Wiggin, Thomas H. . . . . 165 Broadway, New York, N. Y.
Wigglesworth, George . . . . . Room 1004, 53 State Street, Boston, Mass.
Wilder, S. W. . . . . 33 Broad Street, Boston, Mass.
Williams, Albert P. . . . . 278 Crescent Street, Waltham, Mass.
Williams, Dr. Francis H. . . . . 505 Beacon Street, Boston, Mass.
Williams, Henry J. . . . . 161 Tremont Street, Boston, Mass.
Wilson, Charles E. . . . . 11 Central Avenue, Lynn, Mass.
Wilson, H. Carlos . . . . . Lewis Wharf, Boston, Mass.
Wilson, John F. . . . . 90 Chauncy Street, Boston, Mass.
Winslow, Arthur . . . . . 18 Chestnut Street, Boston, Mass.
Winsor, Paul . . . . . 101 Milk Street, Boston, Mass.
Wood, Henry B. . . . . 35 Myrtle Street, Belmont, Mass.
Woodbridge, S. H. . . . . Mass. Institute of Technology, Boston, Mass.
Woodwell, J. E., Terminal Building, Park Avenue and 41st Street, New York, N. Y.

SCIENCE CONSPECTUS

VOL. II DECEMBER, 1911 No. 1

HEREDITY AS AN EXPERIMENTAL SCIENCE

HISTORY OF THE MODERN STUDY OF INHERITANCE—FUNDAMENTAL FACTS UNDERLYING MENDELIAN HEREDITY—DEVELOPMENT DETERMINED BY CHEMICAL COMPOSITION

BY C.-E. A. WINSLOW

PROFESSOR H. H. TURNER, in his presidential address before the Mathematical and Physical Section of the British Association for the Advancement of Science, last summer, sounded a protest against the assumption that experimental science is the only kind worthy of serious attention. Great advances have been made toward theories of fundamental importance by observation and statistical analysis. In many fields, where experiments cannot be made, these methods offer our only hope of advance toward the occupation and control of the unknown. The Darwins who follow such paths are as worthy of honor as the Pasteurs who pursue the road of experimentation. Yet a new and powerful instrument of research has been acquired, whenever any branch of science is brought within the field of experiment. There is, perhaps, no tendency more striking in recent biology than the spread of the experimental method, and in the study of heredity, in particular, its use has been attended with achievements of the first importance.

The history of the modern experimental study of inheritance is bound up with the discovery of a single observer, whose work, neglected at the time, now appears of such fundamental importance, that the whole method of study is called by his name. Gregor Johann Mendel was an Augustinian monk in a monastery at Brünn. His work was mainly teaching in the Realschule, which was then a function of the monastic order, but he divided his energies between the school and the garden of the monastery. Here he experimented on plant breeding, crossing different races of sweet peas, and other forms, and observing the behavior of the hybrids in their subsequent generations with inexhaustible patience and care. In 1865 he reported his results on sweet peas before the Natural History Society of Brünn, and between 1866 and 1873 he described them in a series of letters to the famous botanist, Carl Nägeli. Nägeli was courteous and helpful, but altogether failed to grasp the importance of Mendel's results, and, although the publications of the Brünn society found their way into most of the academies of Europe, no one seems to have noted the work of the obscure Bavarian monastic. Mendel is known to have felt this neglect, as well he might, and is reported to have

consoled himself with the thought "*Meine Zeit wird schon kommen.*" But it came too late. In 1868 he was chosen abbot of the monastery, and in 1872 became involved in a prolonged controversy with the Government, and his researches ceased. He died, unknown to science, in 1884. It was only in 1900 that three different observers, De Vries, Correns and Tschermak, rediscovered the same phenomena, confirming and extending his observations; and the biological world has echoed with Mendel and Mendelism ever since.

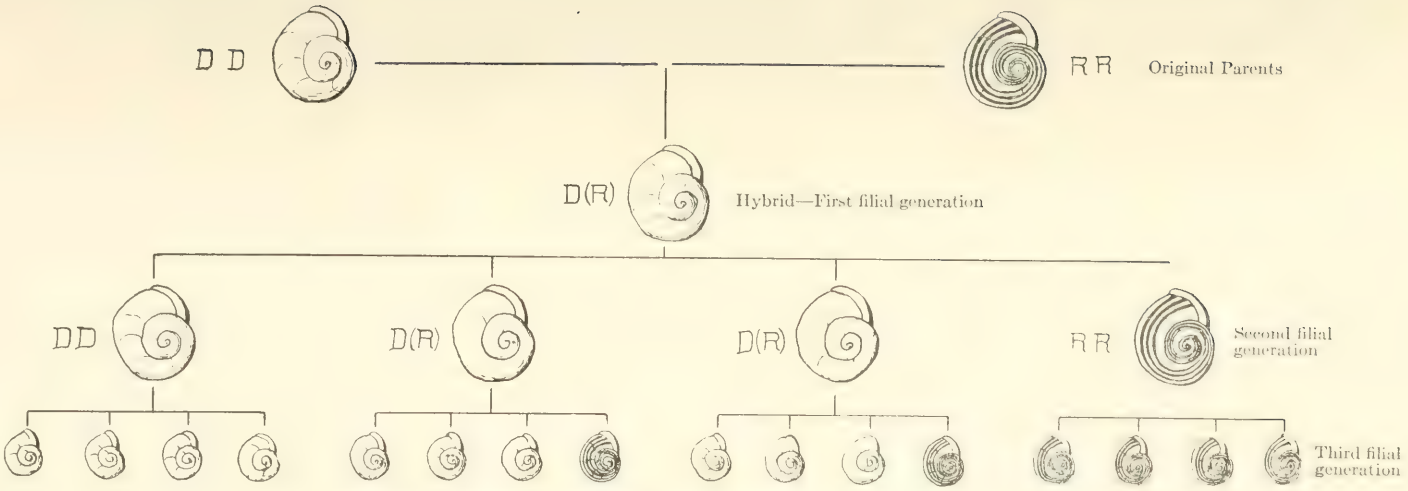
The fundamental facts, underlying what is known as Mendelian heredity, may be best understood by considering one of Mendel's own striking experiments. He crossed a dwarf pea with a tall race. The offspring in the first generation were never intermediate in character but all like the tall parent. When these tall peas of the first filial generation were bred by self-fertilization a very curious but regular phenomenon was manifest. Out of every four individuals in the second filial generation, three were tall and one short. The short individuals all bred true to shortness when self-fertilized. One of each three tall peas bred true to tallness, when self-fertilized, and the other two out of each three tall plants in this second generation behaved like the tall hybrids of the first filial generation, producing in their offspring one pure short plant, one pure tall plant and two tall plants, which showed on still further breeding the power of producing both tall and short individuals.

From this, and from innumerable experiments which have been conducted since Mendel's day, on the colors of animals and plants, on the shapes of flowers and seeds, and leaves, the habit and hairiness of plants, the susceptibility of wheat to rust disease, the presence of horns in certain breeds of cattle, the hair characters of guinea pigs, and rabbits, the waltzing habit in mice, the combs and other structures of fowls and canaries and pigeons, the markings of snails and many other characters, three general principles of Mendelian heredity have been derived, which are expressed in the conceptions of unit factors, dominance and segregation.

The most fundamental of these conceptions, and the one of widest general import, is that of unit factors, factors present in the germ plasm which determine the presence of a certain character in the adult. There is a definite factor, doubtless a chemical substance, which determines tallness, or wrinkled seeds, or a long hairy coat, or immunity against rust. The opposite condition may be caused, merely by the absence of the first factor, or by the presence of another which operates in the contrary sense. It is most convenient in a general discussion to assume two different substances, a shortness-producing compound and a tallness-producing one.

In a hybrid which contains each of the two opposite factors, tending to determine respectively the presence and absence of a character, there is usually no blending. The offspring are all of one kind; as in Mendel's tall peas of the first filial generation. The factor which prevails when both are present is called dominant, and the one which does not, recessive. Tallness in peas is dominant, dwarfness recessive.

The explanation of the observed phenomena in experimental breeding rests on the third fundamental conception, that of segregation. When a pure bred tall pea is crossed with a pure bred dwarf the offspring in the first filial generation will all contain the tall factor, derived from one parent, and the short factor derived from the other. They will all appear tall since tallness is dominant, but they will all be hybrid in composition having within them the potency of tallness from one parent and the potency of shortness from the other. When the germ cells of this first filial generation are formed, however, the two antagonistic factors separate or segregate, so that among both the female cells and the male or pollen cells half contain only the tall factor, and half, only the short factor. Self-fertilization is accomplished by picking out the pollen and applying it to the stigma of the female organ. Under these conditions it will be obvious that on the



Mendelian Inheritance in Snails; Plain and Banded Shell (Lang)
(Diagram by J. H. O'Neill, M. I. T. '10)

The illustration shows the progeny, according to observation, of an unbanded snail which has the dominant character only and a banded one which has the banded or recessive character only, these being indicated by DD and RR respectively. The first hybrids will all of them have both characters with unbandedness only appearing, as the D character is dominant over the R. Mating two individuals of this generation, the D character will meet the D character in one-fourth of the second generation, making a pure strain dominant individual; in half the cases it will meet an R character in which the R will be dormant, the individual resembling in color its dominant grand parent, while in one-fourth the R character will meet the R character and in their union make an R individual. The average number of individuals of each kind is shown as three unbanded to one banded. Now if these second generation animals be mated, the result mathematically is shown in the third generation, ten unbanded to six banded.

doctrine of chances, an average set of four individuals of the next (or second filial) generation will include the following four combinations:

1. Tall male x tall female.
2. Tall male x dwarf female
3. Dwarf male x tall female
4. Dwarf male x dwarf female.

The plants which develop from the first three crosses will all be tall. The first will have only the tall factor in it, and when self-fertilized, will always breed true; the fourth has only dwarfness in it, and will always breed true with respect to tallness and shortness. The second and third will be hybrids like the original first filial generation, and their offspring, after self-fertilization or intercrossing with each other, will repeat the proportion of one pure dominant, one pure recessive and two plants, showing the dominant character, but hybrid in composition.

The case here discussed is a very simple one. When several different characters are concerned, the Mendelian formula becomes more complex. Where two separate variables, like color and flower shape, are concerned, nine individuals, out of sixteen in the second filial generation, show both dominant characters, three show each dominant character combined with the other recessive character and one only shows both recessive characters. Where four separate factors are inherited, an individual, showing pure recessive characters in all of them, will appear only once among 256 offspring. Furthermore, the course of events is complicated in many cases by the fact that two or more separate characters are coupled together, so that one carries the other with it in inheritance. The first case of this kind to be carefully studied was a cross between sweet peas differing in color and in the shape of the pollen. Flowers of either purple or red, produced from this cross, should have shown three examples of (dominant) long pollen to one (recessive) round pollen, but, as a matter of fact, there appear twelve times as many longs as rounds among plants with purple flowers, and three times as many rounds as longs among plants with red flowers. Roundness of seed and redness of flower are associated, as if, in the segregation when sex cells are formed, their unit factors tended to be bound together. Cases of this kind can often be explained on simple assumptions in regard to the coupling of the unit factors, and, when these assumptions are made the results of certain elaborate breeding experiments may be predicted with a high degree of accuracy.

One of the most general phenomena, which appears to fall in the same category with Mendelian heredity, is that of differences in sex. The fact that in every species of the higher plants and animals two different forms of offspring are produced, in approximately equal numbers, offers a problem, whose mystery is only forgotten because of its familiarity. Innumerable attempts have been made to explain this fact, and even to control the production of one sex or the other, but without avail. On the Mendelian assumption that one sex contains only recessive unit factors for sex, while the other contains dominant factors also, the phenomena can be explained with ease. Thus, in the canary, it appears that the female carries a male factor and a female factor, with femaleness dominant while the male has only male factors. When the factors segregate in the formation of the sex cells, all the male sex cells will contain the male factor, while half the female sex cells will contain the male factor and half the female factor. When the sex cells unite, the result will be the production of the two sexes in equal proportions, the males being pure recessives, the females of hybrid nature.

If the male contributes x and x, the female x and y, half the offspring will be x x (male) and half x y (female).

These phenomena can only be assumed, not actually proven, in ordinary cases. In a number of instances, however, it happens that certain obvious characters, like color, are coupled with the sex factors,—there is sex-limited inheritance,—and here it is possible, by observing the character coupled with sex, to study the behavior of the sex factor itself. The results of such experiments tend to con-

firm the assumption that sex behaves as a Mendelian character; and they are in general harmony with the brilliant researches of Professor E. B. Wilson, discussed in SCIENCE CONSPECTUS a year ago, which have shown that, in many forms, the cells which are to produce males and females are distinguished by the presence or absence of a visible morphological structure, the sex,—or accessory,—chromosome.

Professor Johannsen, the distinguished Danish biologist, now visiting the United States, has emphasized the underlying lesson of such experimental work as that of the Mendelian breeders by coining two terms, Phenotype and Genotype. A phenotype is a particular kind of organism, showing certain characters whether as a result of heredity or environment. A genotype is a definite kind of germ plasm, such as is obtained by self-fertilization of sex cells from a pure bred organism. Whatever characters may be temporarily displayed as a result of environment only pure characters will be handed on to future generations by a pure genotype. Different genotypes may produce the same phenotype. Thus a Mendelian hybrid and a pure dominant look alike, but breeding experiments show their genotypical difference. Of course the conception of hereditary and environmental factors in the life of organisms is an obvious and an ancient one; but it has acquired a new precision and definiteness as a result of Mendelian study. Furthermore, Professor Johannsen has shown that pure genotypes are very stable in their qualities. If selection operates on an ordinary mixed population, such as we find in a field of bean plants for example, the average characters may be changed appreciably. If, however, the offspring of a single pure line be obtained by self-fertilization, selection from among the varying phenotypes which arise produces no effect on the race as a whole, each generation reverting to the same average characters. The same thing has been shown in the Institute of Technology laboratories in regard to bacteria. Selection under normal condition is selection among a mixed lot of genotypes. It does not affect the underlying characters of the genotype itself.

It must not be thought that Mendelian heredity is universal, or that even where it occurs it is always susceptible of easy explanation, Many puzzling and complicated results have been obtained, which cannot yet be harmonized with any simple Mendelian formulas. In the inheritance of many characters, Mendelian segregation does not appear to play any part at all. The characters of the parents blend, as in the inheritance of skin color in man. Such phenomena may, perhaps, be due to the fact that the character in question is a product of a number of independent Mendelian factors but this is at present a pure assumption. In many instances of human heredity the Mendelian formulæ are, however, clearly evident. The absence of pigment factors in the iris of the eye is recessive to the presence of pigment. Thus, blue-eyed individuals are pure recessives for this character and have only blue-eyed offspring. Certain pathological conditions, like that in which the fingers lack one joint, and like congenital cataract, are simple Mendelian dominants. Night blindness, the condition in which the individual cannot see in a dull light, has been traced in this way through nine generations going, back to the seventeenth century.

The importance of these researches in their bearing upon human life is not negatived by the fact that strict Mendelian heredity has only been demonstrated in the case of a few simple characters, like those just mentioned. The main point is that certain hereditary characters of plants, and animals, and man, have been shown by experiment to be transmitted in accordance with simple laws so as to give predicable results. The facts point clearly in these cases to the presence of definite unit factors, chemical substances, or complexes of substances which act as determinants of the characters of the adult. Whether the problem can be worked out in all cases by the same formulæ, or by any simple formulæ, is a minor question. It has been worked out in a sufficient number of cases to furnish

strong support for the conception that inheritance consists in the transmission of specific chemical substances, and for the conclusion that this chemical basis is of supreme importance in determining the development of the organism in after life. As Professor Bateson said in his inaugural address at Cambridge University, "We have long known that it was believed by some that our powers and conduct were dependent on our physical composition, and that other schools have maintained that nurture not nature, to use Galton's antithesis, had a preponderating influence on our careers, but so soon as it becomes common knowledge—not a philosophical speculation, but a certainty—that liability to a disease or the power of resisting its attack, addiction to a particular vice, or to superstition, is due to the presence or absence of a specific ingredient; and finally that these characteristics are transmitted to the offspring according to definite predicable rules, then man's views of his own nature, his conceptions of justice, in short, his whole outlook on the world, must be profoundly changed."

THE AUSTIN DAM

The query that naturally comes to the non-professional reader after the failure of a dam or large engineering structure is, "Can engineers determine with accuracy how to build such structures so that they will do the legitimate work for which they are intended without failure?"

It will be reassuring to the public to know that it is entirely possible to build such structures so that they will do their duty without failure. In building a dam, the fundamental thing for the engineer to know is the character and condition of the underlying strata, in order that he may be certain it will carry the load that is proposed to be put upon it; if there is any possibility of water percolating through it, beneath the dam; and especially to find whether or not there is a geological fault on the proposed site. It is obvious that an exact knowledge of the condition of the foundation is absolutely necessary. A competent engineer will take measures to find out the facts and these being known, an absolutely safe dam can be built.

In the last ten years two so-called Austin Dams have failed, one located at Austin, Texas, and the last one at Austin, Pa. The failure of the Austin, Texas, dam was due primarily to its location upon a known geological fault. This dam slid carrying a portion of the rock underneath it with it. Had it been built beyond the location of the fault it would have stood probably without any question.

The failure of the Austin, Pa., dam was due primarily to the percolation of water underneath the dam. It was badly designed and poorly constructed. Its failure was also primarily due to its sliding, carrying certain portions of the rock foundation with it. One report states that there was not sufficient bond or adhesion between the different courses of the concrete. In explanation of this, we will say that after a course of concrete has been placed and leveled off and allowed to remain until the next day, a milky substance called "laitance" rises to the top of the concrete while it is setting. This substance has little strength and is useless as a bonding material. It must be thoroughly cleaned off before another course of concrete is placed. There is some evidence that this was not done in the case in question.

The underlying cause of failure seems to be undue economy in the engineering. Failures similar to this one are often due to a mistaken idea of economy in the engineering work, skimping of material and lack of competent inspection. Money spent in securing the services of a competent engineer is always a good investment.

L. E. M.

FUEL FOR THE FUTURE

Mr. Joseph A. Holmes, director of the United States Bureau of Mines, states that the deposits of lignite in the United States cover 116,700 square miles of which 53,000 square miles are in Texas and 31,000 square miles in North Dakota. Investigation shows that this lignite is suitable for manufacture of briquettes on a commercial scale for fuel purposes.

TESLA'S ROTARY MACHINE

IF THE THERMAL EFFICIENCY OF THIS ENGINE IS AS CLAIMED, THE PRIME-MOVERS OF THE WORLD WILL BE CONSIGNED TO THE SCRAP-HEAP

BY CHARLES W. BERRY

An ideal engine would involve both thermal and mechanical perfection.

Thermal perfection would insure the elimination of heat conduction losses so that that portion of the heat energy theoretically available for work might be utilized. Mechanical perfection would involve simplicity of construction, certainty of action, reversibility, uniform rotative effect, small cost of construction and no depreciation. The present important types of prime movers—reciprocating engines and turbines—meet these requirements unsatisfactorily. In thermal efficiency they are nearly equal, what the one loses in heating and cooling the cylinder walls the other dissipates in nozzle friction, and from imperfect utilization of the energy of the jet. Mechanically the turbine for certain loads seems to possess an advantage because of its more constant rotative effect, but its complexity vastly exceeds that of the reciprocating type. The large units of both types are very complicated in construction and there seems to be no possibility of making any radical simplification.

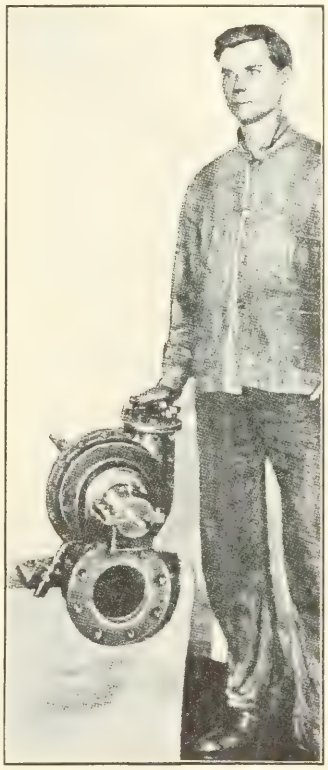


Fig. 1. Size of the Tesla Turbine. A 110 horse-power machine in the hand of the man who runs it

Innumerable efforts have been made to perfect a rotary engine which should combine the relative simplicity of the piston type with the constant rotative effect of the turbine, but unfortunately these accentuate the heat losses due to heating and cooling of the cylinder walls, so that their thermal efficiency has not, at least up to the present, been satisfactory.

It was thought by many that the last word had been said in engine design—that from now on improvements would consist merely in perfection of detail. But now without any preliminary notification Tesla has given a new type of motor to the engineering world for which he is making great claims. He states: *"Here is a simple structure, a casing with two entrances, disks arranged on the shaft and outlets in the center for the escape. In this instance the power is applied to one of the openings and the fluid moves with decreasing velocity toward the center until its energy is exhausted and transferred to the shaft. If the theory is correct I am able to take out the entire energy of steam in one single stage. In the present turbine, sixty-five per cent is the limit of efficiency; theoretically I should be able to get ninety-nine per cent of the total energy of the steam on the shaft in these turbines. A machine will develop ten

** Electrical Review and Western Electrician,* May 20, 1911, p. 988.

horse-power for every pound of weight. This principle can also be applied to the gas turbine. . . . We have a prime mover which is reversible, ideally simple, of enormous torque, incomparably greater than the turbine possesses."

This prophecy unless substantiated to a certain extent by actual accomplishment could hardly hope to hold public attention, but later publications have shown that turbines of this construction are in actual operation and apparently obtaining creditable results.

There are two turbines installed at the Edison Waterside Station, New York. Each of these develops 200 horse-power in a single stage with atmospheric exhaust when running at 9,000 revolutions per minute under a boiler pressure of 125 pounds. Each turbine, which weighs less than two pounds per horse-power, is contained within a space measuring 2 feet by 3 feet by 2 feet in height. The consumption under these conditions of maximum output is thirty-eight pounds of saturated steam per horse-power per hour.† One may be permitted to wonder just how the steam consumption was measured, as the large condensers of the Edison Station are scarcely adaptable to such small units, but the fact that such figures are quoted brings this motor within the reach of engineering possibilities. The engineering world will await with considerable interest the publication of any further information until Mr. Tesla is willing to impart it.

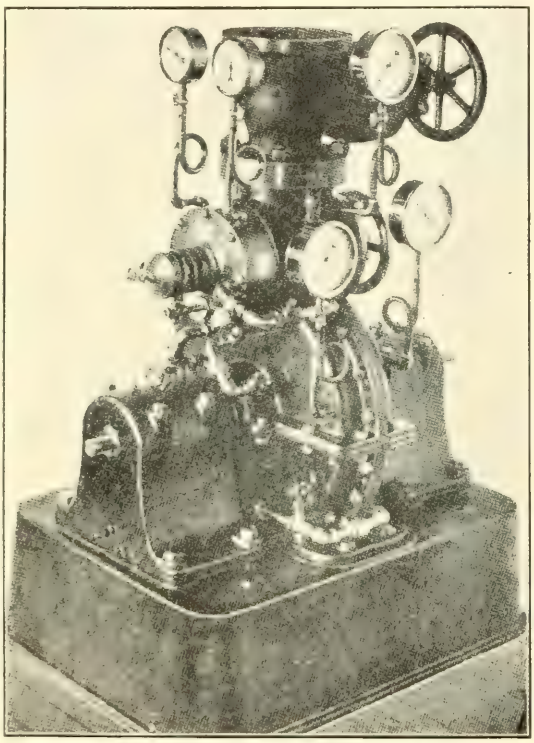


Fig. 2. A 200 horse-power Tesla Steam Turbine

The compactness,* general appearance,** and internal construction*** of the turbine are shown in figures 1, 2 and 3. The rotor consists of twenty-five flat disks, one thirty-second of an inch in thickness, of hardened and carefully tempered steel. The face of the rotor is 3½ inches wide and its diameter 18 inches. The rotor is mounted in a casing which is provided with two inlet nozzles; one for use in direct running, the other for reversing, the reversal being effected by simply turning a valve. Openings are cut out at the central portions of the disks and these communicate directly with exhaust ports formed in the side of the casing. Mr. Tesla sums up the mechanical advantages of his engine as follows: ††"It is simple, light, and compact, subject to but little wear, cheap, and exceptionally easy to manufacture, as small clearances and accurate milling work are not essential to good performance. In operation it is reliable, there being no valves, sliding contacts, or troublesome vanes. It is almost free of windage, largely independent of nozzle efficiency,

† *Scientific American*, September 30, 1911, p. 297.
* *The Literary Digest*, October 28, 1911, p 733, 2d col.
** *Ibid*, p. 732; *** p. 733, 1st col.
†† *Electrical Review and Western Electrician*, September 9, 1911.

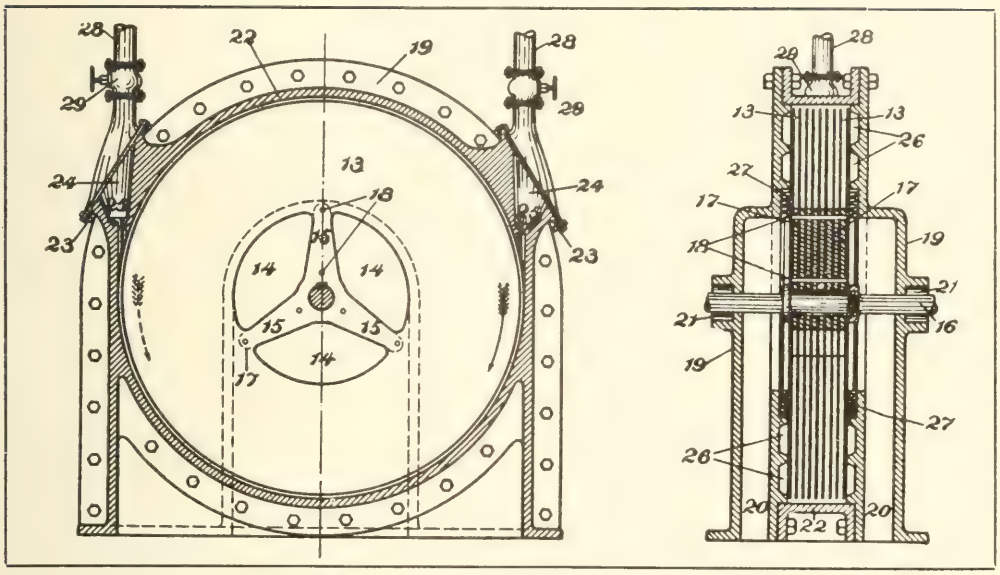


Fig. 3 Fig 4

Sectional Views of Turbine

and suitable for high as well as for low fluid velocities and speeds of revolution. The principles of construction and operation are capable of embodiment in machines of the most widely different forms and adapted for the greatest variety of purposes."

Ordinarily engineers look upon friction as a thing to be avoided and yet at first sight it would seem as if Tesla relied upon friction to operate his motor. "This new principle * consists simply in the utilization of the fluid's internal friction and its adhesion to a smooth surface for giving it speed or imparting to machinery its speed already acquired. The operation is thus vastly smoother than in any known pump or engine, and wasteful and injurious jerks are eliminated, as well as complicated parts." It is interesting to note Tesla's own description of the action of his motor.**

"It is known that a fluid possesses, among others, two salient properties; adhesion and viscosity. Owing to these a body propelled through such a medium encounters a peculiar impediment known as "lateral," or "skin resistance," which is two-fold: one arising from the shock of the fluid against the asperities of the solid substance, the other from internal forces opposing molecular separation. As an inevitable consequence a certain amount of the fluid is dragged along by the moving body. Conversely, if the body be placed in a fluid in motion, for the same reasons, it is impelled in the direction of movement.

"In the practical application of mechanical power based on the use of a fluid as a vehicle of energy it has been demonstrated that, in order to attain the highest economy, the changes in velocity and direction of movement of the fluid should be as gradual as possible. In the present forms of such apparatus more or less sudden changes, shocks and vibrations are unavoidable. Besides, the employment of the usual devices for imparting to, or deriving energy from a fluid, as pistons, paddles, vanes and blades, necessarily introduces numerous defects and limitations and adds to the complica-

* *The Literary Digest*, October 28, 1911, p. 732.
** *Electrical World and Western Electrician*, September 9, 1911, p. 515.

tion, cost of production and maintenance of the machine.

"The purpose of the invention is to overcome these deficiencies and to effect the transmission and transformation of mechanical energy through the agency of fluids in a more perfect manner, and by means simpler and more economical than those heretofore employed.

"This is accomplished by causing the propelled or propelling fluid to move in natural paths or stream lines of least resistance, free from constraint and disturbance such as occasioned by vanes or kindred devices, and to change its velocity and direction of movement by imperceptible degrees, thus avoiding the losses due to sudden variations while the fluid is receiving or imparting energy.

"The greatest value of this invention will be found in its use for the thermodynamic conversion of energy. Reference is now made to Figs. 3 and 4,* illustrative of the manner in which it is, or may be, so applied.

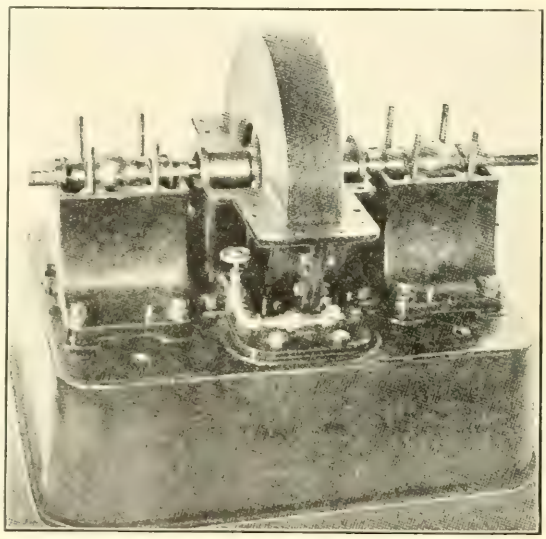


Fig. 5. Turbine with upper casing removed. The cluster of thin disks looks like a solid wheel

"A runner is provided made up of disks (13) with openings (14) and spokes (15) which, in this case, may be straight. The disks are keyed to and held in position on a shaft (16), mounted to turn freely in suitable bearings, not shown, and are separated by washers (17) conforming in shape with the spokes and firmly united thereto by rivets (18). For the sake of clearness but a few disks, with comparatively wide intervening spaces, are indicated.

"The runner is mounted in a casing comprising two end-castings (19) with outlets (20) and stuffing boxes (21), and a central ring (22), which is bored out to a circle of a diameter slightly larger than that of the disks, and has flanged extensions (23) and inlets (24) into which finished ports, or nozzles (25) are inserted. Circular grooves (26) and labyrinth packings (27) are provided on the sides of the runner. Supply pipes (28), with valves (29), are connected to the flanged extensions of the central ring, one of the valves being normally closed.

"With the exception of certain particulars, which will be elucidated, the mode of operation will be understood from the preceding description. Steam or gas under pressure being allowed to pass through the valve at the side of the solid arrow, the runner is set in rotation in clockwise direction.

"In order to bring out a distinctive feature assume in the first place that the motive medium is admitted to the disk chamber through a port, that is, a channel which it traverses with nearly uniform velocity. In this case, the machine will operate as a rotary engine, the fluid continuously expanding on its tortuous path to the central outlet. The expansion takes place chiefly along the spiral path, for the spread inward is opposed by the centrifugal force due to the velocity of whirl and by the great resistance to radial exhaust. It is to be observed that the resistance to the passage of the fluid between the plates is approximately proportional to the square of the relative

* *Electrical Review*, p. 316.

speed, which is maximum in the direction towards the center and equal to the full tangential velocity of the fluid. The path of least resistance, necessarily taken in obedience to a universal law of motion, is virtually, also that of least velocity.

"Next assume that the fluid is admitted to the disk chamber not through a port, but a diverging nozzle, a device converting, wholly or in part, the expansive energy into velocity-energy. The machine will then work rather like a turbine, absorbing the energy of kinetic momentum of the particles as they whirl, with continuously decreasing speed, to the exhaust.

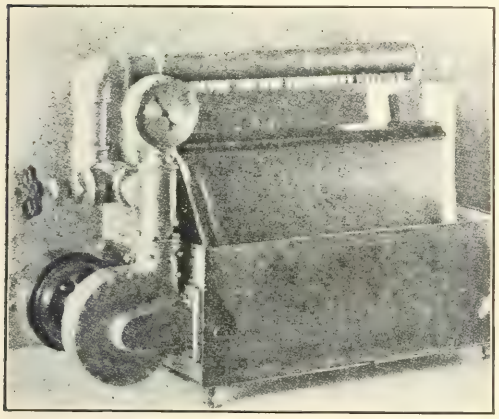


Fig. 6. This little pump, driven by a $\frac{1}{12}$ horsepower motor, is shown delivering 40 gallons of water a minute against a 9-foot head

"The above description of the operation is suggested by experience and observation and is advanced merely for the purpose of explanation. The undeniable fact is that the machine does operate, both expansively and impulsively. When the expansion in the nozzle is complete, or nearly so, the fluid pressure in the peripheral clearance space is small: as the nozzle is made less divergent and its section enlarged, the pressure rises, finally approximating that of the supply. But the transition from purely impulsive to expansive action may not be continuous throughout, on account of critical states and conditions, and comparatively great variations of pressure may be caused by small changes of nozzle velocity.

"Still another valuable and probably unique quality of such motors or prime movers may be described. By proper construction and observance of working conditions the centrifugal pressure, opposing the passage of the fluid may, as already indicated, be made nearly equal to the pressure of supply when the machine is running idle. If the inlet section be large, small changes in the speed of revolution will produce great differences of flow which are further enhanced by the concomitant variations in the length of the spiral path. A self-regulating machine is thus obtained bearing a striking resemblance to a direct-current electric motor in this respect, that, with great differences of impressed pressure in a wide open channel the flow of the fluid through the same is prevented by virtue of rotation. Since the centrifugal head increases as the square of the revolutions, or even more rapidly, and with modern high-grade steel great peripheral velocities are practicable, it is possible to attain that condition in a single-stage machine, more readily if the runner be of large diameter. Obviously this problem is facilitated by compounding. Now, irrespective of its bearing on economy, this tendency which is to a degree common to motors of the above description, is of special advantage in the operation of large units as it affords a safeguard against running away and destruction."

Tesla claims that his machine if driven by external power may also be used as a pump, either for delivering water against a head, or for compressing gas. When considerable pressures are required, staging or compounding may be resorted to in the usual way. The last illustration* shows a small pump driven by a motor of 1-12 horse-power which delivered forty gallons of water per minute against a nine-foot head.

In these machines the stream impact used in turbines has apparently been

** Scientific American*, September 30, 1911, p. 296.

A view of the Austin (Pa.) Dam from down stream. Illustration from the *Engineering Record*

replaced, at least to a certain extent, by the direct impact of the individual gaseous molecules against the molecular inequalities of the rotating disks, but as the spaces between the successive disks are considerable there must still exist a relative displacement between the gaseous molecules at the center and at the surfaces of the stream, so that fluid friction losses must occur. That is, in this new type of motor, as well as in the turbine, there must be a continual dissipation of kinetic energy of translation in the direction of stream flow into the erratic vibration representing heat. The process will thus involve a growth of entropy with a resulting loss of availability. It is difficult to be as optimistic with reference to this motor as the inventor appears to be, but it is well to remember that it possesses such obvious mechanical advantages over the ordinary reciprocating and turbine engines as to secure it a permanent position as a prime mover, even if its thermal efficiency should prove to be considerably less than that of the present types. If, on the other hand, its thermal efficiency should prove to be equal to or better than that of the present engines, its advent will herald the beginning of a new order of things. There will exist but small excuse for complicated valve construction with reciprocating engines, and none whatever for the present turbine constructions. Therefore, considering the evident mechanical simplicity of this motor, as well as the uncertainty as to its steam economy, the engineering public is entitled to await with unbiased mind the publication of experimental data obtained under rigorous test conditions.

The mechanical engineering department of the Massachusetts Institute of Technology hopes before long to be able to furnish such data, as Mr. Tesla has kindly offered to furnish one of his two-hundred horse-power motors to Mr. E. C. Schell, 1912, for his thesis investigation.

AFRICAN RAILROAD BUILDING

Reports from the African Midland Railway would indicate that construction trains were running to a point about 450 miles west of its eastern terminus, Dares-Salem, during the month of September. This would leave about ninety-three miles to be built to reach Tabora which is 160 miles directly south of Lake Victoria. The Colonial Government hopes that the Reichstag will provide means for the further extension of about 200 miles to Uji-ji on Lake Tanganigika giving a line nearly 700 miles long from the Indian Ocean westward.

This road is about 500 miles south of the equator. Africa is about 1,800 miles in breadth on this parallel.

In a test on reinforced concrete piles made with a wood core surrounded by concrete and wire mesh, they showed a breaking load of 210 tons, equal to 3,118 pounds per square inch. The test piles were 19½ feet long and had an area of 154 square inches at the small end.

THE PRINCIPLE OF RELATIVITY

THE NEW IDEAS OF SPACE AND TIME WHICH HAVE MARKED AN EPOCH IN THE MODERN THEORY OF PHYSICAL PHENOMENA

BY D. F. COMSTOCK

WITHIN the last few years no new conception of things in physical science has been so widely, or for that matter, so hotly discussed as the so-called "Principle of Relativity." The principle has come into existence through generalization from a great many experimental results and has therefore more than an aesthetic dignity. The general nature of the conceptions comprizing the so-called principle may be stated in a few words thus. Both space and time are relative and depend on the point of view. The distance between two fixed points or the time between two events depends entirely on the relative motion of the observer who wishes to make the measurement. A moving train is actually shorter than the same train at rest and the watches of all the passengers run a little too slow, these things being true because of the very nature of time and space. In the case of the train the differences are far too small to notice but it nevertheless serves as an example.

All this is very vague, no doubt, but we hope to make things more definite as we proceed.

Considerations respecting space and time have in general been supposed to be the exclusive business of philosophers, but singularly enough, the development of physics has gone on so far toward the fundamental in the past few decades, that physicists are forced, whether they will or no, to play philosopher to this extent at least and to reconsider with care these fundamental realities. The curious and interesting thing, however, is that the physicist has not gone "hunting trouble" as it were, in this respect, but has been forced to adopt new space and time conceptions by the very experiments which he is carrying out on his laboratory table. Thus, led by experiment, and continually relying on it, he is advancing on to ground which a few years ago would have been called metaphysical and into a region extremely fundamental into which it has generally been thought experimental inquiry could never go.

A further curious and important fact about the results reached is that our ordinary, vague, common sense ideas of space and time are not *quite* in harmony with the new ideas taught by experiment. I have emphasized "quite" because they are very nearly in harmony, and it will be a long time before the differences between the two will be felt in the work-a-day world, if indeed, they are ever felt. But to those who are not satisfied with the superficial view of "the man in the street," the deviations are of very great importance because they require our fundamental conceptions to be somewhat modified.

Of course, new ideas which disturb somewhat the old familiar notions of time and space, cannot make their appearance and propagate without a great deal of opposition. And this has been noticed on all sides; under the flag of "The principle of relativity," there have been a great many battles fought of late, but there is this curious fact to be observed as to the personnel of the combatants, that the opponents of the principle of relativity are chiefly those who by their own confession, have not studied the question closely, or even studied closely the experiments on which the ideas are based. In some ways, the present discussion on the principle of relativity reminds one of the story of the early days of the

NOTE. The same author has written a popular article dealing with the elementary mathematics of the principle of relativity, which was published in *Science*, May 20, 1910.

Copernican theory, and as at that time, so now, the weapons of the opposition are the old familiar weapons of conservatism and do not include among them any new ones of recent manufacture.

Having thus discussed in a general way, the general bearing of the new ideas, let us come down definitely to their nature. The keynote of the new principle is, that *two events which to one observer appear simultaneous will not so appear to another observer if he is moving with respect to the first.* To make use of a very crude analogy, suppose a man riding on a train passing a station and a boy standing at each end of the station and now suppose the two boys blow whistles at the same instant. Then if all measurements could be made with superhuman accuracy, the observer in the train would say that the boy who stood at the end of the station farthest in the direction in which the train was going, blew his whistle later than the other. This disagreement has nothing to do, whatever, with the question of the velocity of sound but is far more fundamental. From the modern point of view it is inherent in the nature of things. On the other hand, for the thing is completely reciprocal, if we imagine the man on the train, to arrange by means of delicate instruments or otherwise, two simultaneous events, one toward the front of his train, the other toward the rear, and to do all this with what I have called superhuman accuracy, an observer on the platform of the station would say that the two events were *not* simultaneous, but the one toward the front of the train had happened later than the other. Thus, whenever there is an appreciable distance between the places where two events happen, there is, according to the modern views, an ambiguity with regard to *when* the events happen, this ambiguity depending on the motion of the observer who passes judgment.

It is also true according to the principle of relativity that if the man in the train possessed a perfect clock, exactly similar to another perfect clock in the station, it would appear to run slower to an observer on the station platform, *no matter how he measured the speed*, while exactly an opposite judgment would be passed by the man in the train, namely, that the station clock ran slower. As has been already stated, it must be understood that these differences of opinion are not due to any faulty measurement, or to either observer being "wrong" in any way. The reason is far more fundamental than this, being, in fact, involved in the very nature of time and space.

The reason that this discovery, if we may call it such, as to the ultimate relations of space and time, was not made before, is, that the effects are so extremely small. The fundamental natural unit of velocity in the physical universe seems to be the velocity of light, 186,000 miles per second, and hence from nature's point of view, any velocity is "small" which is not somewhere near comparable with this enormous speed. The mathematical formula, therefore, which states *how much* more slowly the train clock runs than the station clock, contains the ratio of the velocity of the train to the velocity of light, which is so absurdly small that it could not possibly be noticed with any such crude arrangement as the one we have used for illustrative purposes.

It is also clear from the minute size of these discrepancies why there is to all of us a certain repugnance to accepting the new ideas. Our experiences have led us to think of time as absolute and totally independent of the point of view, because our experiences totally neglect any but large and crude effects. In this same way, primitive man doubtless overlooked for years the fact that hot bodies are as a rule larger than the same bodies cold. We may easily imagine a primitive man arguing, if he could argue, that it was clearly ridiculous that the same piece of stone could have any but one fixed size, and having been forced by the cold facts to admit, that nevertheless the same body can grow larger by being heated, accepting the "new ideas" with the greatest repugnance.

As far as primitive intuitions go, the new ideas of the principle of relativity may never be as easy to assimilate men-

tally as the old ideas. Our experiences have all been with speeds which from nature's point of view are very minute and the principle of the new ideas would never have come into existence were it not for the study of phenomena involving vastly greater velocities.

We have a rather close analogy in the dawn of the idea of the round earth. As long as men had experience only in small areas, the earth appeared flat, and even now for all their daily experiences in the work-a-day world, it *is* flat, but the exploration of vaster regions, both terrestrial and astronomical, showed that the simple idea of a flat earth was wrong. The analogy, however, goes further; for, despite the verbal familiarity of the idea of a round earth, the conception is not one which our minds take up easily, for no one can visualize clearly, as Herbert Spencer has so well pointed out, this inconceivably enormous sphere with its surface on which we stand spreading out in all directions, and finally curving until it meets 8,000 miles below our feet. We have, what Spencer calls, a "symbolic conception" helped by the memory of a little model held in our hands.

Had the earth been 10 miles in diameter instead of 8,000 miles, no one, except perhaps primitive man, would ever have had the conception of a flat earth, and similarly with respect to the new ideas, had the velocity of light been 300 feet a second instead of 186,000 miles, we would have had very different ideas of space and time.

The new ideas have thrown light on many phenomena hitherto in darkness. Thus there is a well-known experiment in physics of letting light pass through a rapidly moving stream of water and measuring with very delicate instruments how much the light is carried along with the water. Now beforehand we might expect one of two things, either the light is totally dependent on the water, in which case it would be carried along with it like a boat on a river or the light is independent of the water in which case the flow of the water would have no effect on the light as a river has no effect on an island in it. The experimental result is, however, quite different, for we find neither of these expected results but rather the very puzzling one that the light *is carried along* but with about *one fourth* the velocity of the water. From the principle of relativity, the case is clear, for, since motion is relative, an observer imagined moving with the water would see the light doing exactly what we see it do in "stationary" water, and it is our fundamental disagreement with this moving observer which introduces the mysterious 3/16 into our measurement. How far is the sun from the zenith? The answer depends on the *place* of the observer. How fast does the light move through the water? The answer depends on the *motion* of the observer.

It would be inconsiderate of the reader if I multiplied further descriptions of experimental results and it must suffice to say that, so far there is not a *single* experimental result which seems to contradict the principle of relativity, while there are a great many experimental results which it explains with ease.

Doubtless much of the foregoing will not be clear, but the reader can have this consolation at least, that difficulty in dealing with the principle of relativity is felt by everybody at the present time, even by those who know the most about it. The ideas have not been simplified yet, have not, that is, been worked down into the form in which they fit easily into a high school physics, but we must remember that there was a time when no one understood the principle of the conservation of energy very well, whereas now, it properly belongs in the most elementary books.

Already there is a German book with "The Principle of Relativity" as its title, and in English text-books we may expect at least a chapter with this title before long. At any rate, the principle represents a series of extraordinary concepts, apparently in deeper harmony with the real world than the corresponding older ones, and a distinguished European scientist goes so far as to say that the principle of relativity can only be compared with the Copernican system in the far-reaching nature of its implications.

THE SMALL CAVE HOUSES OF ARIZONA

RELICS OF A PEOPLE THAT LIVED IN THE CLIFF DWELLINGS OF WALNUT CANYON MORE THAN A THOUSAND YEARS AGO—PROBABLY ANCESTORS OF PUEBLOS

BY H. W. SHIMER

WALNUT CANYON is one of the more easily accessible of the many localities of the southwestern United States where cliff dwellings occur. One may walk or ride the eight miles from the railroad station of Flagstaff out through a pine-clad, rolling upland until quite suddenly the trail ends at the edge of a gorge 350 feet deep. At first glance one sees only the steeply descending sides, with small pines and undergrowth clinging closely to the talus slopes of the softer strata. Directly, however, one distinguishes three horizontal, cave-like grooves running along its face and about half way up from the bottom of the gorge and in each groove artificial walls, dividing it into separate compartments.

Walnut Canyon, 350 feet deep, and the pine-clad rolling upland into which it is cut

The geologic structure of the region explains the formation of caves and their adaptability for occupation as homes. The gorge has been cut into a plateau of upper carboniferous rocks. Above the cross-bedded sandstone into which the lowest part of the gorge is cut, these rocks consist of horizontal beds of limestone of varying hardness. This variation in hardness renders the successive layers variable in their resistance to weathering, the more resistant remaining as ledges projecting out over the softer, more easily eroded bed below. It is in three such cave-like grooves formed by the erosion of the softer rock between these resistant beds that the cliff dwellings occur, a compact bed of limestone some twenty feet thick forming the roof, while another resistant bed forms the floor. These cave layers extending along the steep slope of the canyon are divided into separate dwellings by transverse walls built out from the back to the front of the cave.

One house of average size measured 15 feet in length, 10 feet in width or depth, and from 7 feet in height at the front to 4 feet at back. The floor had been made approximately level by filling in the down sloping front part with mortar. The

front of the house is an artificial wall two feet thick built of native rocks of varying sizes joined by a yellowish brown mortar of rather coarse sand such as is found in the bottom of the canyon. This front wall reaches from the floor to the overhanging ledge and is pierced at the center by a door nine inches wide at base, which though now broken away above was apparently originally less than five feet high. Against the roofing ledge directly over the door is a round hole of four inches diameter, apparently a smoke outlet. The transverse walls forming the ends of the house are similar in thickness and material to the front wall which they join at a right angle.

That the fire was built in one of the back corners of the house is evidenced by the soot on the adjoining walls and roof and by the presence of charred corn cobs, bones and bits of wood. Fragments of pottery indicating vessels of many sizes and shapes from jars to platters are extremely abundant both in and about the houses, especially on the slopes in front.

A Walnut Canyon cliff dwelling showing the resistant stratum above and the character of the masonry.

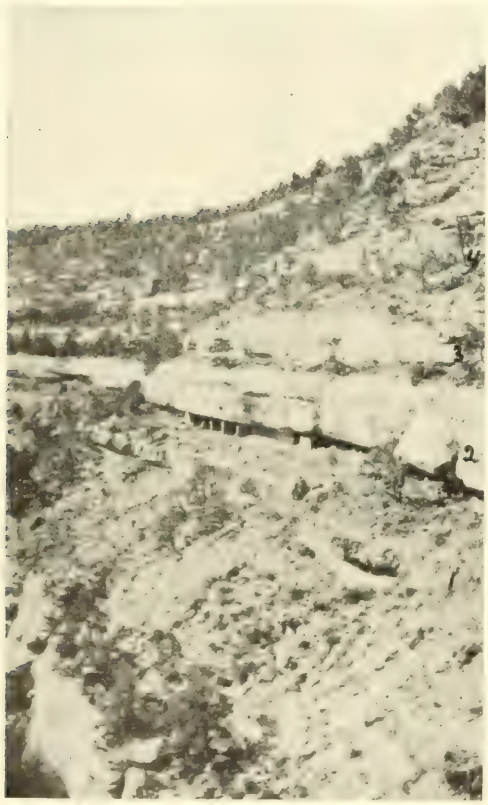
There were doubtless many tribes of this ancient Indian stock varying in degree of culture and in the development of communal life. Many large community cliff houses have been found in the southwestern United States and remains of artificial irrigation canals. Such remains indicate the development of a greater co-operation than do the small cave houses developed in response to the conditions at Walnut Canyon. In this plateau region the horizontal bedding and alternate hardness of the rocks form caves and in response to these natural conditions the cliff-dwelling type of house arose, just as the polar region developed the snow house, treeless plains the portable tents of skin, and broad dry valleys, mud or adobe houses. Doubtless, likewise, the nomadic tribes to the north made utilization of these caves necessary for the self-preservation of these more peaceable Indians of Pueblo stock.

Our knowledge of the life of these builders of the Walnut Canyon houses has been amplified by remains found in the other cliff houses of supposedly kindred peoples. They made much pottery, probably mostly of the type formed by coiling long clay rolls round and round in the shape of the jar desired. Of the fibers of yucca leaves they made sandals and wove cloth. That they were not an aggressive people seems indicated by the relative scarcity of weapons among the cultural remains. No iron implements have been found, hence they were probably wholly in the stone age of development. Their chief weapon apparently was the flint-headed arrow. Their food included deer and turkey, corn, beans and melons.

The abandonment of these homes by their once numerous inhabitants is generally explained by the gradual encroachment of desert conditions into this southwestern region. Such a process of drying up is indicated at present by the dead

forests and by the lack of young growth in much of the existing forests. It is considered that the water courses have gradually shrunken and the area of tillable land has decreased, so that the country can no longer support such a population as formerly existed.

Most investigators agree that these dwellings have been deserted for about



Side of Walnut Canyon, showing the four resistant beds, numbered, between which the dwellings occur. Most of the dwellings are between the lower beds; a few show in the picture

1,000 years. The dwindled survivors of this people may possibly have been the ancestors of the present Hopi Indians and other Pueblo tribes of Arizona and New Mexico.

The Massachusetts Institute of Technology has received the equivalent of two and three quarter million dollars during 1911.

THE SIBERIAN RAILWAY

The balance sheet of the Siberian Railway shows that it is not a very profitable enterprise. For the three years beginning 1906, the operating expenses were successively 144 per cent. 139 per cent and 124½ per cent of the gross earnings. The deficit in 1908 was $6,693,000, to which should be added interest on the capital stock which is $235,292,862, to find out what Russia is paying for the development of its Asiatic territory and for national defence.

There is some development of earnings on that part of the line which is west of Lake Baikal, which alone the Russians call the Siberian Railway. The line east of the lake is called the Trans-Baikal, and the 570 miles on the Pacific coast from Vladivostock northeastward, the Ussuri Railway. The earnings of these last two have decreased materially since 1906; but the Siberian proper actually had some net earnings in 1908; about $488 per mile, against a deficit of $692 in 1907. There is a considerable amount of cultivable land along this line, and it is nearer the markets for its wheat, butter, etc.

SCIENCE HELPS THE FISHERMEN

It is stated that the Danish Government, under the direction of the biological department at Copenhagen, has come to the aid of the fishermen of the Baltic Sea by providing an ingenious device for the preventing of migration of eels from that arm of the sea to the outer ocean. The *Electrical World* states that the means employed is a barrier of light, formed by placing fifty electric lights along a submerged cable between the island of Fano and the coast of Funen. The eels migrate only during the dark hours, and, accordingly, as soon as darkness begins in the season of migration the lamps are illuminated and a wall of light is thus interposed which the eels are fearful of passing. A similar plan, using submerged lamps, is said to be a favorite resort of Italian fishermen to keep eels from leaving the shallow waters.

LIQUID CRYSTALS AND THEIR FORMATION

INANIMATE BODIES WHOSE GROWTH IN SOLUTION RESEMBLES THE DEVELOPMENT OF LIVING CELLS—SOLIDS AND SUPERCOOLED LIQUIDS

BY ELLWOOD B. SPEAR

To MOST of the readers of SCIENCE CONSPECTUS, the words "solid" and "liquid" carry their own definitions so far as the everyday matters of life are concerned. Webster's definition of solid is,—"capable of resisting up to a certain limit, forces tending to deform," and his definition of liquid is,—"flowing freely like water, fluid, not solid," and as applied to physics, "characterized by free moving of the constituent molecules among themselves, but without the tendency to separate from one another characteristic of gases."

SOLIDS AND LIQUIDS

These definitions do very well for dictionary purposes but in order to show how faulty they are for the uses of science, let us consider a common example. White sugar is obviously a solid, and water a liquid. Further, when the sugar is dissolved in water, doubtless the mixture is a liquid also. If now, we boil this mixture, it gradually becomes thicker and thicker until it reaches a point where, upon being rapidly cooled, it becomes candy having a clear glass-like mass that is apparently solid. If the hot mixture is a liquid, and the cold candy a solid, the question naturally occurs, at what stage of the cooling did the liquid become a solid. This mass of candy is not absolutely rigid and resistant to a change of shape, for even the hardest will bend slightly when pressure is gradually applied to it. If we reheat the mass, it will gradually become softer and if we consider the mass as a solid, there is no definite temperature at which we can say that it has become a liquid.

Suppose we suddenly cool the mass once more and "pull" it as candy is ordinarily pulled. The mass will become whiter and stiffer until it can no longer be pulled without breaking it. If we attempt to heat this pulled candy a second time, we should find that there is a definite temperature at which the solid suddenly changes into a liquid state. Most bodies have a definite melting temperature which scientists use as one criterion to determine the transition from one state of matter to another.

SUPERCOOLED LIQUIDS

There are some substances, however, which do not quickly change from the solid to the liquid, and *vice versa*, at a definite temperature on being heated. Such substances are called supercooled liquids; the candy was a liquid cooled below the temperature at which it will easily flow. Glass is an excellent example of a supercooled liquid. If a long piece of window glass be held horizontally at one end for a considerable period of time it will bend of its own weight showing that its molecules have changed positions somewhat. This change in the molecules is similar to the change in the molecules of a liquid, and metals which are made to assume various shapes under the drop hammer or drawing press are said to "flow."

TRUE SOLIDS

The question may now be asked, is there any fundamental difference of structure between the so-called supercooled bodies and true solids? To enable us to answer this question, let us examine a little more closely a piece of the candy before and after it has been pulled. If we break it with a hammer before it has turned white, we notice that there is no

uniformity in the shape of the pieces. The corners and edges of a fragment form all sorts of angles with each other. On the contrary, the white pulled taffy if broken will resolve itself into numberless small pieces having certain angles and corners that are exactly the same on every piece. These angles are absolutely independent of the size because even if the substance is ground into powder, we should find that under the microscope, each particle has some angles that are an exact reproduction of the corresponding edges on the parent fragment. This is a general law, that every true solid will break along certain lines much more readily than along others. These are called "lines of cleavage."

Crystals

Let us again melt some sugar and allow it to cool very slowly. This time we obtain a large number of small bodies exactly alike in shape having the same angles as our powdered white sugar. We have here to do with another general law, that all true solids assume certain definite shapes if but given an opportunity. Table salt, for instance, always occurs in cubes while sulphur resembles double pyramids. There are only thirty-two of these fundamentally different forms and all others found in nature are either these or combinations of these.

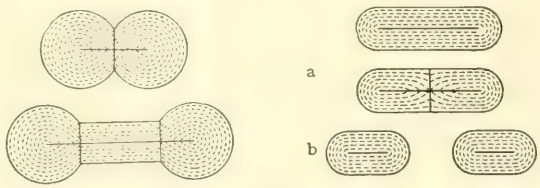


Fig. 1. A diagram showing how some liquid crystals grow, divide into halves and separate in the same manner as living cells

Scientists have offered in explanation of this peculiar behaviour on the part of true solids, that the molecules arrange themselves along certain definite lines. In mobile liquids the molecules are free to move in any direction and are vibrating too rapidly to assume any definite arrangement, but if the liquid is cooled slowly, that is, if the molecules lose some of their kinetic energy,* the forces governing this definite arrangement of molecules get control and the molecules become orderly in their habits once more, forming a body having definite shape. True solids, then, are bodies whose molecules, or groups of molecules, arrange themselves in a definite geometrical manner. A solid is therefore said to be crystalline and each individual fragment is called a crystal. Supercooled liquids on the other hand are hard bodies whose molecules have no definite arrangement and are spoken of as amorphous, meaning without form.

We now see the reason why we can have sugar in two hard forms. If we cool melted sugar so quickly that the molecules do not have time to assume the position they like best, we have clear, amorphous candy. If, however, we pull and work this mass long enough, the molecules, can swing around into a suitable position and we have "pulled" candy which is none other than crystallized sugar. For precisely the same reason that candy crystallizes and becomes sugar, automobile springs break after they have been used for some time. The steel of which they are made is generally "hardened" by plunging the hot metal into water or oil. If the spring is constantly jarred, the molecules gradually assume a more orderly arrangement. Some of the substances in the steel become cyrstalline, and the spring breaks along the lines of cleavage of the crystals.

Liquid Crystals

Of late years, many liquids have been found to have a definite arrangement of the molecules just before the solid form is reached; that is, if the pure liquid substance is kept for some time at a temperature very slightly above that at which the whole mass becomes a solid, liquid bodies like crystal ghosts, are formed and these

*See Science Conspectus, Vol. I, page 51.

bodies have been given the name *liquid crystals*. Most of these substances are of a very complicated structure and have names that are unintelligible to any but a close student of the subject. (See Fig. 3.)

Resemblance of Liquid Crystals to Living Cells

Liquid crystals possess some very interesting properties so nearly allied to the habits of organic life that some scientists have suggested the possibility that these peculiar bodies are an intermediate step or a missing link between living things and inanimate matter. Indeed, no one can watch the formation of some liquid crystals under the microscope without being struck with the marvelous similarity between this method of growth and that of all living matter.

All living things, trees for instance, are composed of tiny particles called cells. These cells absorb molecules of suitable substances which penetrate into the inside and are assimilated just as animals eat and assimilate food. When now, the cell becomes too large, it divides in the center and becomes two new cells just as bees divide into swarms and leave the old hive when their numbers become too great. This is called cell division and is the method by which all animate matter grows. Ordinary *solid* crystals can be made to grow, it is true, but the new matter is always deposited on the outside of the crystal. Liquid crystals on the other hand, absorb molecules of the same substance into the inside of the crystal just as living cells do. Very often the crystal divides into two parts and these repeat the process of division as soon as they have absorbed sufficient material. The two halves often remain united by a band and subsequent growth begins at both ends. Sometimes the increase in size is very much greater in one end than in the other or takes place faster on one side of the crystal. This gives a wiggling motion to the whole particle. If this distorted growth is very rapid, it appears to the observer as though tiny snakes were being formed in the solution with incredible rapidity. Figures 3 and 4 are actual photographs of living crystals in the process of growth.

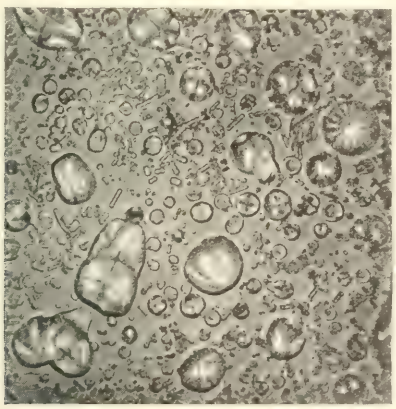


Fig. 3.

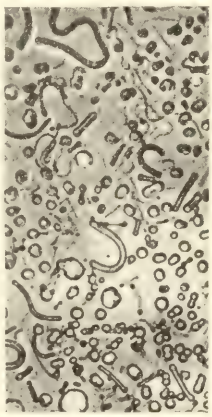


Fig. 4.

Actual photographs of liquid crystals of para-azoxycinammicethylester in process of formation. In the right hand one can be seen the wiggling worm-like bodies already referred to

EROSION OF BRITISH ISLES

The erosion of the British coast has been studied by a royal commission which has recently handed in its report. Six thousand six hundred and forty acres have been eroded within a period of thirty-five years, while 48,000 acres have been gained by accretion and reclamation. The loss has been more serious on the east coasts of England and Ireland, but it is not sufficient to cause alarm.

THE MILK SUPPLY OF BOSTON

DANGERS OF THE MILK SUPPLY AND WATER SUPPLY COMPARED—CERTIFIED AND PASTEURIZED MILK—RIGID INSPECTION BY CITY AUTHORITIES

BY SAMUEL C. PRESCOTT

We are inclined to think of water supply and sewage disposal as the great sanitary problems of cities. Important as these are, the questions of proper milk supply, proper food supply, proper housing, and proper regulation of the dangerous, infected, or diseased individuals will appear of equal gravity when we study them from the standpoint of general community welfare, and note accurately the relation of each to the health of the citizens.

This paper, however, can touch only on one of these subjects, milk supply,—and this in but an incomplete and superficial way.

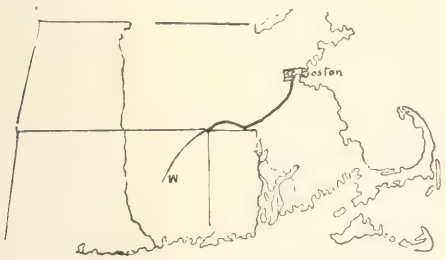
Milk is perhaps, next to water and bread, our most important food substance, for it is a commodity of almost equally general use. For the very young it is a necessity, for it is the natural food. It contains all the elements necessary for the upbuilding of the body, and it contains them in combinations and proportions which make it, under normal conditions, a perfect food. This matter of composition in itself is of the utmost importance, because with our increasing knowledge of bacteria, germs, or microbes, we have learned that more than almost any other food, milk may readily be changed from a substance of the highest value to a most dangerous and death-breeding medium if it happens to become infected with pathogenic or disease-producing organisms. Fortunately the worst types of these infections are relatively rare, or we should be constantly having epidemics due to this cause.

As compared with the water supply of a city the milk supply problem offers certain points of similarity and others of marked contrast.

Let us follow the development of each as a community passes from rural to urban conditions. Under rural conditions the water supply is the shallow well, or a near-by spring or brook. Under the same conditions the milk supply is the family cow or herd, essentially, however, a domestic supply. With village conditions the wells may be retained, or a not remote river, or springs or wells may be tapped for the general supply. The milk supply in like manner is removed away from the actual household environment, but still relatively near and easy of access so that the milk may still be obtained in a fresh if not in a clean condition. With the large city the sources, in each case, are pushed still further away, as the demands for quantity increase, and as the suburban regions become too valuable to be given up to uninhabited watersheds or even to dairy farms. In this factor of distance from consumer, then, and in the demand for quantity, water supply and milk supply for a large city are alike, but here the analogy ends, for having thus reached out into a remote region, the water supply is, in general, in a sparsely settled region, and not subject to the contamination or pollution due to intimate contact with human beings. A watershed may be subjected to sanitary supervision and control, and the matter thereby protected in great measure. Is this true in milk supply? Assuredly not. Hardly any substance which enters our mouths as food is more subject to contamination;—from dirty cows, from dirty utensils, dirty men and dirty methods. So obvious is this, in fact, that many people never really know the true taste of clean cow's milk, and always assume that the *cowy* tang is the real taste rather than the flavor of the dissolved and suspended cow manure.

Now, there is another point of difference. Milk is an ideal bacterial food, while water is not. If therefore we have each of these commodities equally infected with intestinal bacteria the germs will die out gradually in the water, or be starved out, while on the other hand they will develop and increase with lightning-like rapidity in milk unless counteracted in some way.

In the matter of transportation to the city, too, there are great differences, and this has also a bearing on our general subject. The water is brought in by conduits or pipes, generally covered and protected from infection, and distributed to the consumer by service pipes, still protected. It is therefore either at the source or at the point of consumption that noxious germs may enter a water supply.



Milkshed E—Elm Farm Creamery

With milk, on the other hand, unless the most assiduous care is observed, the supply is subject to infection from human and other agencies at every point from the cow to the consumer; at the farm, on the road, on the railroad, in the milk-house, on the delivery wagon, and even in the very kitchen of the consumer himself. As a matter of fact this is probably in many cases a most important and dangerous point of infection.

It is because of these facts, combined with the almost universal use of milk, that those who are interested in health problems look upon the milk problem as one of the very greatest gravity, and for most cities far more serious than the question of water supply.

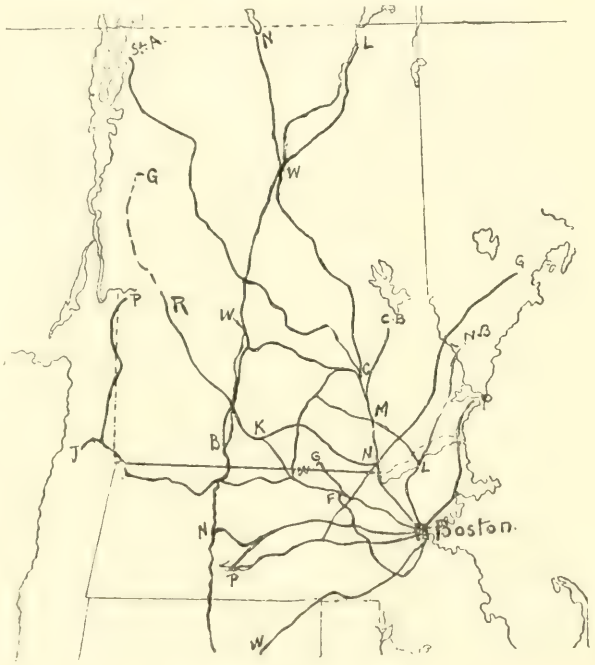
Evidence of the importance of this question is shown by the volume dealing with Milk Supply and Public Health, published by the Public Health and Marine Hospital Service in January, 1908, and reprinted in enlarged form in 1910.

The importance of milk as an article of food may be considered from two distinct standpoints, first, from the actual standpoint of food substance or food value, second, from the standpoint of its safety and wholesome character.

From the first standpoint we should examine milk with reference to the amount of food, the amount of total solids, the proteins, and the amount of milk sugar. For the total solids and the fats definite standards have been formulated by the different states; in Massachusetts, for example, it is required that the milk shall contain at least 12.15 per cent of total solids, and 3.35 per cent of fats. Standards in other states depart somewhat from these figures. This variation in standards is due in part to the fact that we find great variation in the actual composition of cow's milk, and any standard, therefore, is but a compromise and represents simply, more or less fairly, the average composition of milk from all kinds of cows, or from the prevailing strain or breed. Different breeds of cows differ markedly in the relative amount of fat and of protein which the milk contains, and different animals in the same breed or strain also show great differences on these points. Since there are such wide variations to be found in the natural milk of healthy cattle it becomes reasonably apparent that the examination for fats and solids only is of no special importance, so far as the healthfulness of the milk is concerned, and the results of such examinations give us information only as to whether the purchaser is obtaining food which conforms to the specified state standards which have been erected. In other words, analysis of milk with reference to fats and solids is carried out simply as a means of protecting against fraud rather than from any standpoint of wholesomeness or effect on the health.

The examination of milk with reference to the number of bacteria and the kinds of bacteria contained in it has, however, a totally different basis,

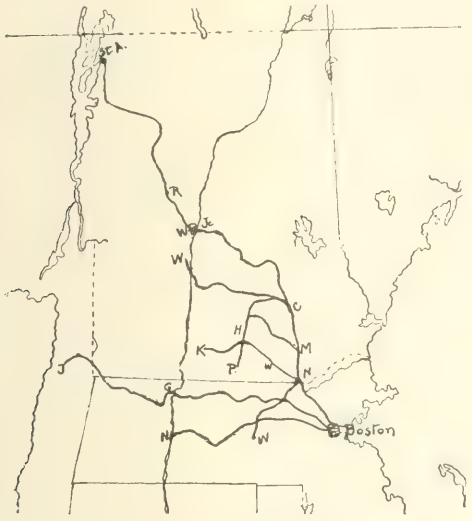
for it is now well understood that the wholesomeness of milk, or its effect upon the health of the consumer, is markedly affected by its bacterial character. Milk, as it is secreted by the healthy, clean cow, and obtained under clean conditions, shows very small numbers of bacteria, and these of types which produce change in the milk but slowly. If, on the other hand, the milk is obtained from dirty cows, with no special precautions as to cleanliness in production or in handling, the numbers may be very large and the kinds of bacteria may be very numerous. Furthermore, many of these kinds will have the power of bringing about a rapid change in the milk, fermenting the sugar to lactic acid, splitting the proteins to products of putrefaction or other forms of decomposition and affecting the fat, perhaps, also to a slight degree. Furthermore, the organisms themselves may be of such a character that when introduced into the human intestinal tract they produce serious disorders, particularly in children, and become a menace to health either directly or through the products of protein decomposition to which they give rise.



The Milkshed of Boston

Milk obtained from clean, healthy animals under aseptic conditions may be called normal milk. Relatively small amounts of such milk are found in the supplies of great cities. Certain farms, however, make a specialty of producing normal milk, or approximately normal milk, by conforming rigidly to principles of cleanliness or to certain requirements which may be laid down by some organization such as the Medical Society, and such milk is generally spoken of as "certified" milk because it may receive a certificate as to its chemical and bacterial quality from such a commission. In many cities another grade of milk, not conforming to such rigid requirements as in the case of certified milk, but yet produced under clean conditions and under constant inspection, is sold under the general name of "inspected" milk. Such milk generally contains under 50,000 bacteria per cubic centimeter. By far the major portion of the milk sold in large cities, however, is subject to much less rigid inspection than this, and we therefore need not be surprised to find the number of bacteria far greater than these figures. Ordinary city milk, as it may be called, will sometimes be found to contain anywhere from a hundred thousand bacteria to hundreds of millions for each cubic centimeter, depending upon the demands of the enlightened portion of the public or the vigor with which milk campaigns have been waged by the health authorities. In many places the large numbers of bacteria are destroyed or held in check by the process of pasteurization, by which we ordinarily mean the heating of the milk to a temperature of from 140 degrees to 170 degrees for varying lengths of time,

whereby the majority of the bacteria will be killed. True pasteurization consists in heating the milk to a temperature of from 150 degrees to 165 degrees for a period of from twenty to thirty minutes, and this process is extremely effective in

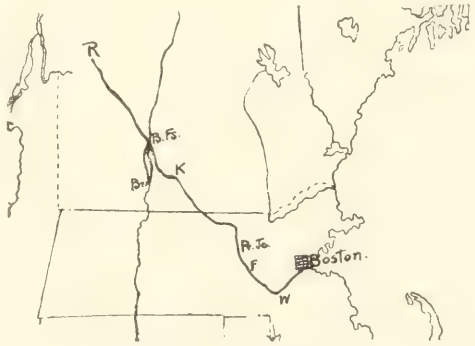


Milkshed A—D. Whiting Sons

the destruction of organisms since practically all, with the exception of the more resistant or spore-forming types, will be destroyed. Commercial pasteurization may be carried out, however, using these temperatures for very short periods of time, and while the destruction of bacteria is marked, the percentage of organisms destroyed will not be as great as in true pasteurization.

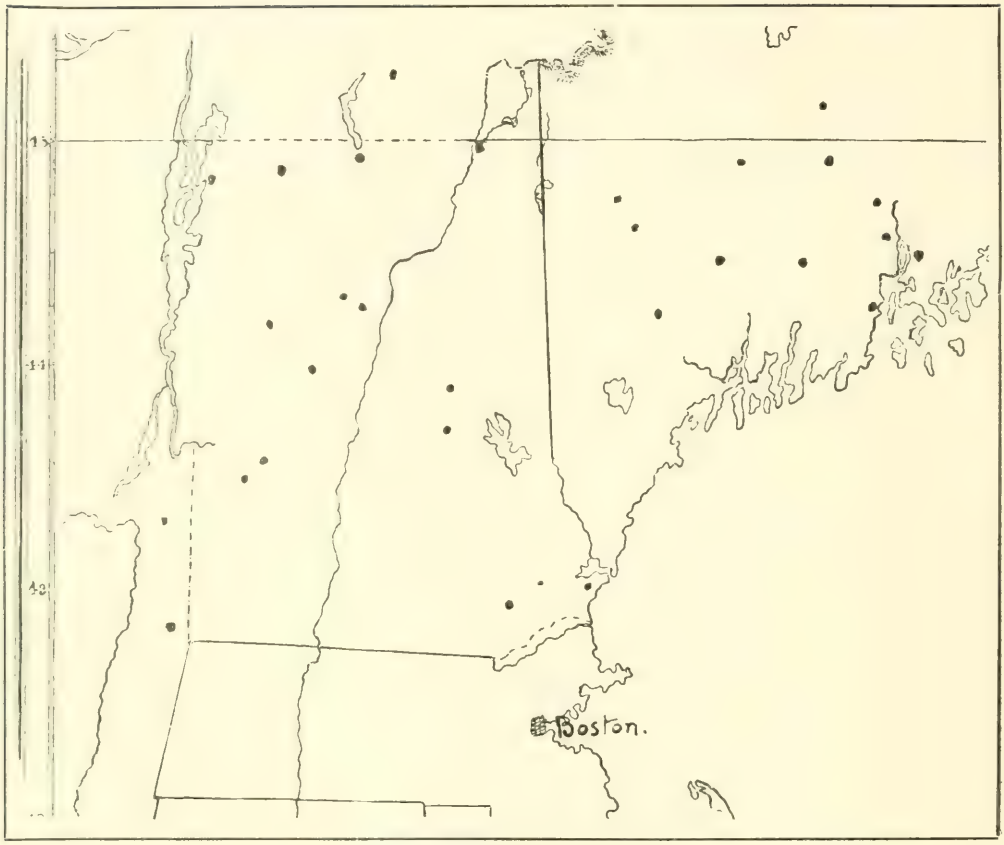
Having thus defined the kinds of milk with which the inspector or analyst has to deal we may consider the milk supply of Boston with reference to quality and the relative amounts of certified, pasteurized, and ordinary milk. According to the most recent available figures the average daily consumption of milk in Boston is slightly in excess of 250,000 quarts. For the whole metropolitan region this figure is nearly doubled. This vast quantity of milk is derived from between six and seven thousand farms scattered throughout the states of Massachusetts, New Hampshire, Vermont, and portions of Maine, New York and Connecticut. There are about two hundred and seventy-five dealers by whom the milk is sold to the consumers, although approximately 85 per cent of the business is really concentrated in the hands of less than a half-dozen large dealers, commonly known as contractors. Many of the smaller dealers buy their supplies direct from the contractors and serve merely as a second ring of middlemen between the producer and the consumer. Something less than half of one per cent of the whole milk supply of Boston, or about 1030 quarts daily is "certified" milk. Several thousand quarts daily would fall under the general head of inspected milk, were this term commonly used in this city. From 60 to 65 per cent of the whole supply of the Boston milk has been subjected to some process of heating with the intent of destroying the bacteria, although it is not sold under the name of "pasteurized" milk.

One of the most remarkable facts in connection with the Boston milk supply lies in the fact that almost three quarters of it comes from outside the state of Massachusetts, and much of it from great distances. The maps which are shown in this article give a general idea of the farthest shipping points and the routes over which the milk travels to reach the



Milkshed F—Alden Bros.

city. The farthest of these shipping points is Newport, Vermont, a distance of about 235 miles. The result of the fact that the city has to reach out so far into the surrounding country in order to



Some of the Foci of Cream Supply

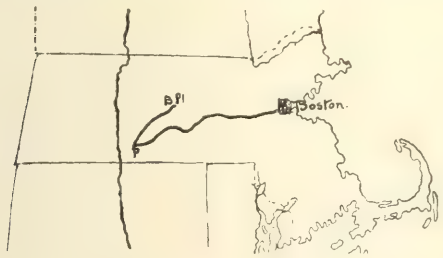
get an adequate supply is that the age of the milk when it reaches the city is likely to be considerable, and much milk is from forty-eight to sixty hours old when it gets to the doorstep of the consumer. Bearing in mind the great activity of the micro-organisms, it is not surprising that some of this milk should be of undesirable quality, and much of it would be unfit for food were it not for the fact that the process of refrigeration, and consequently of the inhibition of the bacterial development, had been brought up to a high standard of efficiency through the use of special milk cars with ice compartments and the liberal use of ice during the transit from the shipping point to the milk-house of the contractor.

In order to guarantee fair quality of milk to the consumer the city health department maintains an office and laboratory devoted to the subject of milk inspection. Here, samples amounting to approximately 20,000 per year, are submitted to analysis, part as to the proportion of fats and solids and a part with reference to bacterial count. About one third of the analyses are carried out from the bacteriological standpoint. These samples are collected by inspectors from the various dealers, from the cars as the milk is received in the city, or from delivery-wagons, or they may be taken from the various sorts of shops where milk is for sale. The larger dealers also maintain inspectors, chemists, and bacteriologists to look after their own particular portion of the supply. During the year 1909, 15 per cent of the chemical samples examined by the city milk inspector fell

below the legal requirement of either fats or solids or both. The bacteriological samples are examined to determine whether the total numbers of bacteria exceed an arbitrary number,—500,000 per

Milkshed G—Plymouth Creamery Co.

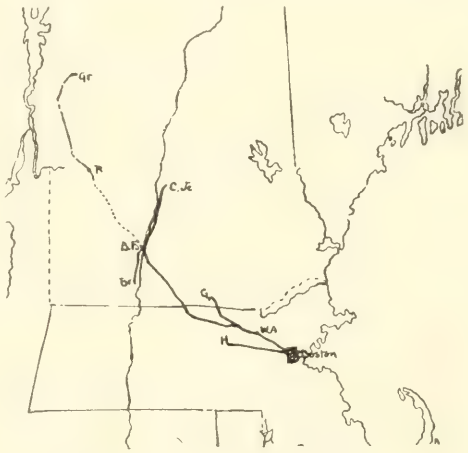
cubic centimeter—which the city board of health established several years ago, and during the year 1909, approximately 11 per cent of the bacteriological samples exceeded this figure. Notwithstanding this, it is unquestionably true that the Boston milk supply is much better at the present time than it was before the inspection work was conducted so assiduously, and it may furthermore be added that the Boston supply compares very favorably with the supplies of other large cities. It may fairly be questioned if any large city in the country has a general supply superior to that found here. The quality of the milk from the food standpoint will also bear comparison with that found in other cities. The average percentage of fat is about 3.5, and the average percentage of total solids from 12.3



Milkshed C—C. Brigham Co.

to 12.4, while in New York the corresponding figures are approximately 3 per cent and 11 per cent.

While, as stated above, the milk supply of Boston compares favorably with that of other cities, it is still capable of great improvement. The conditions on the farms are in many cases unsatisfactory, due to ignorance or carelessness on the part of the farmer, or sometimes due to labor difficulties, scarcity or high cost of assistance. Disagreements between producers and contractors as to the price to be paid and other features of the contracts between them, and the greatly increased cost of cattle feeds, have also tended to exert an influence on the whole question of quality of the milk and care in its production. If the farmer cannot receive a fair rate of compensation or a fair profit for his milk, he is, not unnaturally, unwilling to exert the increased care and clean-



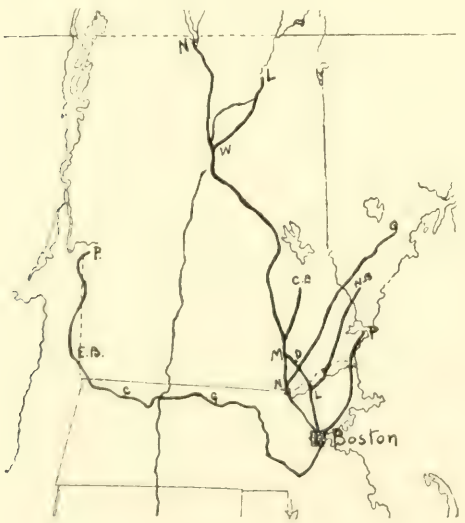
Milkshed D—Boston Dairy Co.

liness which the contractor, spurred by the city inspector, is constantly requiring.

A feature of the Boston milk supply which is more highly specialized here than in other cities is to be found in the method of handling after the milk reaches the city. During transportation the milk is contained most commonly in cans of 21 1-4 quarts capacity, or the familiar Boston can of 8 1-2 quarts capacity. On reaching the milk-house of the contractor the milk from possibly several hundred farms is dumped into a large tank provided with stirring apparatus, so that the quality, so far as fats and solids are concerned, may be reasonably

uniform. The bottling of the milk, therefore, instead of being done in the country is done in the city after this indiscriminate mixing has taken place. From the mixing tank the milk is pumped to the various other forms of apparatus,—heaters, coolers, filters, etc., and eventually finds its way to the bottling machines where it is put in the glass jars or bottles ready for distribution to the consumer. The milk-house has undoubted advantages in that a milk of relatively uniform quality is assured. There are, however, certain disadvantages, because if the milk from a particular farm is infected with the germs of disease these germs are distributed throughout the large volume of milk and so may go broadcast throughout the city.

The relation of milk supply to infant mortality cannot be discussed here, yet it should be borne in mind that these two subjects have a very intimate connection. We know that the cities having the clean milk supplies are those which have the lowest infant death rates, and it is probably true, also, that the more emphasis



Milkshed B—H. P. Hood & Sons

is placed on conditions of cleanliness at the farm, and especially in keeping the cows themselves clean and healthy, the more certain it is that there will be a direct and beneficial reaction upon the general health of the community. The time has come when the milk problem must be regarded as a most serious and important one, not to be settled by

Milkshed H—Deerfoot Farms Dairy

radical or foolish legislation, but by the united efforts of those who are concerned with milk production and sale as a business enterprise; those who are competent to deal with the problems of transportation and handling as engineering problems and particularly those who, through actual scientific knowledge and the results of investigation, can consider in a large and fair-minded way the general relation of milk to health.

THE CENTER OF POPULATION

Mr. E. Dana Durand, director of the Census Bureau, states that the center of population of the United States is located in the western part of Bloomington, Monroe County, Indiana. Since 1790 the center of population has moved 558 miles westward, but in the last ten years it has only moved thirty-nine miles in that direction. This is largely due to the fact that the population of New York, Pennsylvania, and some of the other near-by states has balanced the growth of Texas, Oklahoma, Indian Territory and southern California.

SOCIETY OF ARTS LECTURES

The lectures before the Society of Arts will begin in January. Arrangements for four lectures are being made but the total number may be increased to six. Due notice will be given to the Society.

SCIENCE CONSPECTUS

VOL. II JANUARY, 1912 No. 2

SOME NEW FACTS ABOUT WHALES

PRINCIPAL GROUPS NOT RELATED TO EACH OTHER BUT ARE DESCENDANTS OF DIFFERENT LAND ANIMALS—DO WHALES EVER SLEEP

IN A course of three lectures before the Lowell Institute Professor W. Kuekenthal presented a story of the whale which is perfectly up to date. In this he not only showed that many errors exist in popular conceptions, but that even important matters are not known to the investigators, for example, whether whales really sleep. The lectures abounded with items of general interest, which can be but hinted at in an account like this. With a word about the whales not being fishes Doctor Kuekenthal stated that they are descended from land mammals which have become modified in their life in the water, and further asserted that the fossil whales, now extinct, the whalebone whales and the toothed whales are descended at different geological times from different land animals. There is no link between the fossils and the toothed whales, and none between the latter and the whalebone whales. In this there was argued a principle of convergence, by which the animals from different sources adapting themselves to similar conditions resemble one another. This is the reason for the similarity between whales and fishes.

Some of the difficulties in the study of whales were shown, the fact that they cannot be confined in an aquarium, that they must be observed at sea, and that the ideas of those who are not scientists must oftentimes be discredited. The sailor, the speaker said, is not reliable as an observer of matters that do not directly interest him.

One of the things on which the lecturer threw light is the distribution of whales. They are not all of them marine animals, but some live in the brackish water at the mouths of rivers and others in the rivers themselves, hundreds of miles from the mouths. There is a dolphin in the Elbe, another in the Amazon and a third in the Ganges, the last named of which is eyeless or with the eyes atrophied.

Another difficulty in the study of whales is that they are heavy and their organs are unwieldy. The great mass of flesh when it decays makes such stenches that dissection is carried on with difficulty.

The distribution of the whale is practically universal. Some are special to the Arctic oceans, but in general, now that the species are being closely studied, the evidence shows them to be limited only by the food supply and they will go wherever this food is to be found. They swim all the time, are true pelagic ani-

mals, but are limited in their approach to the shores by shallow water and rocky projections. The number of species is not known, it having been a habit of the naturalists to give species from different localities different species names. It is evident that some kinds are common to the two oceans and the speaker noted that about two hundred and fifty species have been named of which perhaps ninety are valid. There is great variability, the males, females and young having different forms and in the opinion of Professor Kuekenthal, there is cross-breeding, although this is difficult to prove.

One of the most interesting chapters in the new story of whales was that referring to their embryos. It was shown by the comparison of pictures that the youngest forms of the whale are like those of a mammal, in fact, very like those of man, with head, small neck and fore and hind limbs, the latter of which disappear as the embryo grows older. The nose and mouth openings are near together, the nasal hole traveling as the embryo develops to the top of the head in the whale. The speaker relies in part upon this similarity in the embryos for his statement that whales are descended from land mammals and give evidence of the great difference between these embryos and those of fishes. He also disputed energetically all hypotheses which seek to place the origin of whales among the now extinct saurians. The discovery that whales have hairs, which is one that Doctor Kuekenthal has made, makes it the more evident that they are descended from land mammals because the hair is a mammalian characteristic. In some of the embryos there is evidence of a mustache, in others of the grown whales a beard of about one hundred and fifty hairs has been noted, while in other species hairs on the head number about as many. This makes it out of the question to term this a hairless animal.

Why some other animals living in the water, the sea otter and the seal, have not lost their hair, but on the contrary have developed most beautiful fur, was explained by the speaker as due to the fact that these creatures are not yet fully adapted to the water, and since they pass much of the time on rocks or on ice, the fur has become necessary. In the place of the hair, the whale has developed an interesting heat retainer, a layer of blubber, filled with oil, that envelops the whole body beneath the skin.

Professor Kuekenthal assembled an enormous amount of information in his three lectures. He noted that in some species the hairs, which by the way are the highest development, the tactile hairs, have altogether disappeared and in place of them there are what may be sense organs susceptible to pressure. In some such way, the adaptation of these to pressure, the speaker accounts for the unanimity with which whales will dive, remain under water and rise again, though so far distant from one another that vision between them is out of the question. Whale meat is good to eat, but being close to the blubber which is filled with oil it must be thoroughly separated from this to be palatable. The question was raised whether whales sleep. There are a number of theoretical reasons which have been urged in the negative. A whale has been known to follow a steamer in the South Atlantic for twenty-four days, during which time it could not have slept. Some French naturalists argue against the possibility of the whale maintaining its balance in the water if asleep. On the other hand the *Deutschland* killed a whale by collision with it and it is asserted that this one was asleep, while Professor Kuekenthal reported to science that he had observed the white whale asleep. The speaker believes in the sleep of whales and thinks that there may be some automatic action which gives the animal way enough to keep it in equilibrium. In this as in many other matters observations are necessary. These must be made quickly now or the opportunity will be lost, for the extinction of the whale is at hand unless some international legislation is instituted to regulate the matter of its capture.

One of the items that this authority set right was the so-called spouting of whales. Almost since time immemorial the idea has prevailed that whales spout

Sulphur bottom whale spouting; Placentia Bay, N. F., Sept., 1903

water through their blow-holes, and even recent text-books carry along the fiction. What has been taken for fountains of water by sailors and others is in reality the breath of the whale charged with moisture. It may be likened to the visible breath of a man on a frosty morning. The reason that it is visible is still something of a puzzle. The lecturer suggested that the breath of the whale is sent out from the lungs under powerful pressure and the expansion of it as it reaches the free air induces cold which makes the vapor visible. The fact that young whales do not blow nor do the larger ones on hot days, seems to support this suggestion. An excellent picture from the collection of Glover Allen, secretary of the Boston Society of Natural History, is very suggestive of the latter hypothesis and shows how different from a column of water the true spouting really is.

Incidental to this statement there was quite an exposition of the mouth and nasal anatomy. The blow-holes connect with the lungs directly and there are water-tight muscular rings at the point of crossing of the gullet. The mouth has no real connection with the nasal passages, so that it is impossible for the water taken in at the mouth to be thrown out at the blow-holes.

There are a number of different arrangements of blow-holes; some whales have two that are distinct, while in others the holes unite just at the skin, so that these whales can spout but one stream. The holes are set at different angles, so that one skilled in the whaling profession may identify the species by the character of the spoutings.

Another interesting question was with reference to the diving of whales. The motion was shown, the whale curving its body, pointing its head directly down

and oftentimes going so directly in the vertical that the flukes of the tail rise above the surface of the water. The depth is subject to some uncertainty on account of the difficulty of observation. There are examples in which the line to the length of 3,000 feet has been taken by the whale in a dive after being struck, the evidence being that the creature swam directly down, coming up later in the same place where it had disappeared. The sperm whale does not go so deep, but in 800 feet of water it is said that one ran against the bottom so hard as to plunge his head into the mud.

The creature that goes to the depth of two or three thousand feet in the water is subjected to enormous pressure, at the latter depth the lecturer said being equivalent to about a ton per square inch of surface. It is natural, therefore, to expect special devices fitted for this pressure. The most remarkable of these is the supplying of blood to the brain, not by the carotid artery, but by a special one which finds its place in the outer coating of the spinal cord within the spinal column. The eyeball is also adapted to extreme pressure, being as solid almost as a cannon ball. Then there are other devices like valves for the apertures which fit the animal for deep diving. Evidence points to the fact that the old fossil whales were deep divers also.

In point of feeding whales may be divided much like land animals into pasturing and predacious. The grazing animals are not strictly herbivorous, however, as on land, for although there are enormous quantities of the microscopic plants on the surface where the whale feeds, there are also small crustaceans and other fleshy animals. The mouth is opened and enormous quantities of water enter it. The mouth may be as long as fifteen or twenty feet, so that a boat could float in it and the roof is high in some species, the whalebone whales having there the great plates of whalebone whose ragged edges form the filter in which the organisms catch. When the mouth is closing the water is spurted out, the fauna and flora being caught by the filter, and the tongue crushes them and they glide into the gullet. There is in this connection a curious adaptation in which the furrows of the lower side of the head figure. The tongue is a great mass of muscle about as long as the mouth, but when the mouth is opened the tongue has disappeared. It is in reality forced into the floor of the mouth, pushing down and distending the muscles of the lower jaw. The furrows make the skin elastic, so that it can accommodate the extra material.

The time of whales' remaining under the water between breathings was given as different in different species, from 5 to 20 minutes in the small species and as high as an hour and three quarters in the larger ones.

UNKNOWN PHENOMENA OF MAGNETISM

Several unexplored phenomena of magnetism are referred to in a paper by Doctor Steinmetz recently presented before the Franklin Institute. One relates to permanent magnetism and involves an answer to the question, What is permanent in the permanent magnet—the magnetic flux, the mmf, the flux density or distribution, or the magnetic energy? Again, there is no satisfactory explanation of hysteresis—that is, of the loss of energy by a cyclic change of magnetism. Finally, the Heussler and other similar alloys have introduced problems that require elucidation and the magnetic characteristics of oxygen should be studied.

COST OF GOOD ROADS

Mr. Logan Waller Page, director of the United States Office of Public Roads, is authority for the statement that $1,000,000 a day was expended on road construction and maintenance in the United States in 1910; the amount spent in 1904 was $80,000,000 and it was estimated that $140,000,000 was spent last year, which is an increase of 75 per cent. in seven years.

SAFEGUARDING WHOLESOME FOOD

WHAT THE ENFORCEMENT OF THE PURE FOOD LAW INVOLVES—HOW SYSTEMATIC RESEARCH IS MAKING FOOD SUPPLIES BETTER AND CHEAPER

BY A. G. WOODMAN

The enforcement of the Pure Food Law is ordinarily regarded as consisting almost entirely in the collection and analysis of samples of food and drugs and in the prosecution of offenders in the courts. One who has not made a rather close study of the workings of the Federal Act and its various applications can hardly realize the amount of work in other lines that is involved and the numerous ramifications into which the activities of the officials must be carried.

Too often we hear it said by unthinking individuals that the Pure Food Law has been a "failure." Even those whose actual dealing with trade conditions in food and drugs ought to give them a clear knowledge of the true state of affairs will say the same thing, pointing out, it may be, specific instances in which the "law is not strict enough" or in which certain lines of business are unduly hampered or restricted.

I have no intention or desire to appear in the rôle of apologist for the shortcomings of the present law; it is admitted by its friends that it has not accomplished all that was expected of it. Whether this is due to opposition on the part of certain manufacturing interests, such opposition not appearing openly but disguised in many cases as an attempt to improve the working of the law by innocent amendments proposed ostensibly in the interests of pure food; whether it is due to the reading into the law of referee boards that were certainly not contemplated by the framers of the Act; whether it is due to the emasculation of its powers in certain very desirable directions by Supreme Court decisions; it is not proposed to discuss here.

It must be evident to all that radical changes in present conditions of manufacturing and handling foods, desirable as such changes may be from a theoretical standpoint, cannot be instituted without seriously interfering with the business of manufacturers. Such a balance must be maintained between the conflicting interests as will give the best results viewed from all angles, and action should be taken only after due consideration and careful study of each problem.

In order to do this many investigations have to be carried out under diverse conditions and I wish to speak briefly of some of the questions which the enforcement of the food laws has involved directly or indirectly. A consideration of these can hardly fail to show that the subject is so extensive that it is very far from just to condemn the authorities if they fail to move in all directions with the rapidity that some critics would consider desirable.

Some Typical Examples

A typical example of the prolonged investigation which it has been necessary to make in the case of some foods is found in the studies on deterioration in poultry and eggs. This work began with a chemical and microscopical study of the changes which take place in the flesh of chickens in cold storage and has led to an investigation of the methods of handling poultry on a large scale in every stage from the producer to the consumer. It has necessitated the co-operation of merchants, raisers, railways, refrigerator-transportation companies and storage-warehousemen.

Large poultry packing establishments from Kansas to Iowa have been visited, the methods of killing, picking, chilling, packing and transportation observed, and carload lots traced and portions

examined from time to time during transit and in the storage-warehouse. The comparative advantages of drawn and undrawn poultry have been carefully studied on numerous shipments made in warm and in cold weather on a commercial scale, and thousands of analyses made to learn the chemical and bacteriological changes taking place.

Similar investigations have been made in the case of eggs. Eggs of known history, from those of the highest quality to those of the very lowest grades, have been analyzed and studied microscopically after keeping for various lengths of time. It has been necessary to establish small but complete laboratories at various packing centers in order that this study may be made on material gathered at first hand. This work alone has involved the carrying out of over 3,000 analyses.

In addition, much bacterio-chemical work has been done in studying the conditions of the oyster and clam industries. This included inspection of oyster beds, floats, shucking houses, containers and shipping and transportation conditions, and chemical and bacteriological examinations of the products handled. Similar work is being done in the case of mineral springs and bottling establishments. Conditions as regards proper sanitation are noted in factories and other places where food is prepared, such as milk depots, ice-cream factories, bakeries, candy kitchens, hotels, boats, dining-cars and the like.

The spoilage of cod and other salt fish has been studied by an inspector of the Bureau of Chemistry and a special bulletin has been issued on the subject as a result of his work. The specific organisms causing the spoilage have been determined and the conditions under which they increase have been investigated. This information is of immense value to the fish industry and will be of the first importance in improving the quality of the product marketed.

Another example of investigations made under the law of the conditions attending the shipping of food products is the study made of the practice of packing oranges and grapefruit while immature and by a sweating process in steam-heated chambers so changing the color as to simulate the ripe fruit and supply the Northern market in advance of the time of normal ripening. Fruit so treated is inferior to that normally ripened and not so wholesome. As a result of the examination of the material a decision of the Board of Food and Drug Inspection was issued forbidding the practice.

Improving Shipping and Handling

Furthermore, it has been necessary to carry out extended researches, not only into the shipping and handling of food products, but also into the methods and conditions of manufacture, in order to be of benefit to the manufacturers themselves, and also to demonstrate that the requirements of greater cleanliness and the preparation of a high grade product is not a hardship. An instance in point is the manufacture of bottled ketchup. Many laboratory and factory experiments have been made, in order to increase the length of time that the ketchup would keep without spoiling after being opened. It has been shown that ketchup can be prepared, on a large scale, without any added preservative, and have it keep indefinitely before opening and for a reasonable time after opening. Many analyses had to be made of ketchups on the market and methods elaborated by which to show the character of the materials entering into the manufacture of the commercial product and the care used in its preparation. The general appearance of the ketchup, and its taste, color, and smell, may be easily modified by a skilled manufacturer, but no amount of cooking or finishing can change the microscopical structure.

The same line of work was carried out to show the changes in composition taking place during the manufacture of cider vinegar. In co-operation with a large commercial plant tests were made at intervals on 20,000-gallon lots run through generators. Important data were obtained for fixing standards for pure cider vinegar, made necessary by new forms of sophistication. Elaborate

studies on the chemical composition of cider were carried out in the New York laboratory in this connection.

Special investigations that often mean an immense amount of work and extend over a long time are often demanded as the result of the analysis of samples obtained in the routine procedure or of information obtained by the inspectors in the regular examination of factories. The finding of arsenic in the coating of cheap candies sold to children led to a study of the occurrence of this dangerous element in various classes of food products, and the amount present in commercial samples together with the source from which it enters the material is being determined. Many products in which phosphoric acid or phosphates are used in the manufacture, such as syrups, baking powders, gelatin and jams, may have arsenic present in distinct amounts. Just how much is dangerous, and how much, if any, should be tolerated, is a matter that can be settled only after much study.

A thorough study is being made of a large variety of foods put up in tin, and known to be of standard quality. These are being examined from time to time in order to note any changes in the character of the contents and to determine the amount of tin which may be taken up from the can under different conditions.

Another case in point relates to the sale of flour bleached by the use of nitrogen peroxide. Exhaustive studies were necessary in order to show the effect of the bleaching process on the digestibility and wholesomeness of the flour before its manufacture and sale could be properly forbidden. A great amount of labor and time was expended in the preparation of the case on which the decision of the courts was obtained, as it was felt that this was a most important matter. The services of numerous inspectors and leading chemists in the department itself were necessary. Outside experts were secured, and the whole subject examined most exhaustively from the standpoint of physiology and biological chemistry.

Adulteration of Drugs

The subject of drugs forms an important branch of the work of enforcing the Food Law, a branch, moreover, which spreads and divides in many different directions. The officials are concerned with the manufacture of pure drugs and with the prevention of the sale of remedies which are calculated to deceive or defraud the purchaser, either through the character of the material itself or through misleading statements regarding the curative properties of the article.

Take the case, for instance, of the sale of certain essential oils. The manufacturers advertise that their salicylic acid and methyl salicylate, two largely used remedies for rheumatism and related diseases, are made from oil of wintergreen. Physicians have complained of late that those products did not give so good results in use as formerly. The matter came to the attention of the authorities and it was easily ascertained that the small amount of genuine oil of wintergreen produced in this country could not supply the source of all the material which was being sold as natural salicylates. It was found that it was made largely from the related compound, oil of sweet birch. This is not so good, but the substitution is very hard to detect. Studies are now in progress in the attempt to devise methods by which to detect oil of birch and artificial methyl salicylate in the oil of wintergreen.

The requirement under the law that the presence and amount of certain powerful drugs must be declared on the label has made it necessary to examine and improve the methods used for the separation of acetanilid and related substances used in headache powders, and this has been done with marked success.

The chemists under the Food Law also co-operate with the Post Office Department in obtaining fraud orders against medicinal agents represented as cures for various maladies sent or prescribed through the mail. Analysis of samples of the medicine must be supplemented by a study of all the claims and repre-

sentations made for the treatments. The number of remedies in each treatment varies from one to ten, all of which must be examined. Typical of these are the so-called "cancer cures" in numerous cases of which the Post Office Department has issued fraud orders, as a result of which the mail order "cancer cure" business has been largely suppressed in this country. Other cures which have been or are being investigated are for epilepsy, tuberculosis, vitality, eyesight restorers, all of fraudulent character.

Investigating "Cures"

Most of the epilepsy cures are sold by mail, although a few are in the open market. These are second only to the cancer cures in the misleading and deceptive character of the claims made for them. They claim to cure epilepsy independent of its character or duration, absolutely and permanently. Representations are made that the epileptic seizures are less frequent through taking the medicine, the diseased condition of the brain is changed and diseased tissues of the brain are replaced. These claims are, of course, false and misleading in the highest degree. No substance is known in medicine which can replace old or wornout tissues in any part of the body by new. These remedies, by the use of drugs, palliate the severity of the seizures. The relief is temporary and the remedy is not a cure in any sense of the word.

Consumption cures are sold through the mails as well as in the drug stores. So far as can be learned as the result of much investigation and through medical testimony they are not cures; their effect is only temporary. Some, nevertheless, are represented as absolute cures for all forms of tuberculosis. A diagnosis on a blank form, in the absence of the patient, which forms the basis of these "cures," is practically worthless. It is true that millions of dollars are spent annually to prevent consumption, but there is no drug which is a specific for its treatment and the time and money spent on these remedies but delay the proper hygienic treatment which is essential.

Drug-addiction cures have also been given much attention during the past year. Numerous institutions engaged in the practice of treating those afflicted with the opium, morphine, or cocaine habit by furnishing a "treatment" with instructions have been "under fire." It is found, as a rule, that these "cures" contain in large quantities the very drug for which they are being taken. They are sent with no warning as to their dangerous character, and by their use the habit is more firmly fixed upon the unfortunate sufferer. Some of those selling these preparations were found to be unaware of the character of the treatment. It seems incredible that a dangerous drug of this kind should be sent out by a groceryman without any chemical or medical knowledge, but such was the case in one instance. He had purchased the business and simply mailed the treatments to anyone asking them. It is, of course, well known that these habits can be treated successfully only under careful supervision of a competent physician and that the patient is entirely incapable of curing himself. The chief object of these treatments seems to be to extract money from the patients as long as they will respond. Cases are on record where the treatments were supplied for years. Each case of this kind has to be carefully looked into to see how it can best be stopped.

A comparatively recent form of fraud, which receives attention under the Food Law, is the exploitation of so-called "prescription remedies." These usually call for several well-known medicinal agents, together with a coined-name product in the sale of which the advertiser is interested. In order to fill the prescription it is necessary to purchase the agent sold under the coined name. For example, in the preparation of a face lotion, the patient is advised, by a paragraph in the "Beauty Column" of some newspaper, to purchase a cheap, well-known product under a fancy coined name, mix it at home with certain common household agents, among them water, and apply the resulting mixture. A typical one of these, largely sold, con-

sists essentially of magnesium sulphate (Epsom salts), colored and perfumed. The actual cost of a fifty-cent package is not over one cent. Investigation shows these preparations in many cases to be unmitigated frauds.

Fraud in Imported Products

Careful examination and study must be made also of imported products for the presence and amount of harmful drugs. Importations from Oriental countries, ostensibly medicinal preparations, have been found to contain opium or morphine. These products are put up in various forms, as small red pills or tablets coated with cinnabar and wrapped in waxed paper, or in wax globules. They are invoiced under misleading names as "tonic pills," "stimulant pills," "tea cake," etc., and are recommended on the label for coughs, colds or consumption. The statement is sometimes made on the label that they are free from morphine, that they are "perfectly harmless" and "especially beneficial for women and children." Some of them, put up in the form of a pleasant confection, are a source of great danger when coming indiscriminately into the hands of mothers or children who are unaware of their harmful nature. Another preparation containing chloroform and ether, imported as a cough lozenge of value in coughs and colds, was found upon investigation to be sold to school children and others as a form of candy with no notification of the dangerous character of its ingredients. Such practices are of course prohibited, but their thorough investigation requires a great deal of time and labor.

Over one hundred brands of medicated soft drinks have been found upon investigation to contain large or small amounts of caffein and nearly a third of the number contained small quantities of cocaine. The amount of cocaine in each case was small to be sure, but the unrestricted sale of these beverages, often to children and younger people, can readily be seen to be a fruitful source of danger. Persons addicted to the use of these drinks are found to be factory employees, stenographers and others subjected to nervous strain, many spending a considerable proportion of their earnings in this way. Very small amounts of cocaine affect deleteriously the nervous system and the prevalence of the habit is shown by the fact that the large life-insurance companies are considering seriously the status of these soft-drink habitués as future risks.

Nor should the time devoted to inspection of food products be overlooked in a summary of the extent of work necessary, work which does not come directly before the public, but which is nevertheless essential. One or two examples chosen from imported foods will serve as illustrations.

The condition of the figs coming into this country has required much time and study. These figs have been found to be largely wormy or worm-eaten or infested with sugar mites. It has been necessary to pick over each shipment and sort out the figs containing live or dead worms, worm excreta, sugar mites and molds. In order to identify these a study had to be made of the history of the so-called worms, which were allowed to develop in sterile figs, the resulting moth laying her eggs, and the complete cycle was thus followed.

Olives imported in bulk have needed frequent and thorough inspection in order to exclude those of inferior quality, over 90 per cent. of those entering at a single port being found to be wormy and unfit for food.

A large number of shipments of beans from Italy were found to be infested with a small fly, the bite of which produced a rash on the workmen on the docks.

It is hardly necessary to multiply examples further. From what has been stated it will readily be appreciated that there is much work to be done in the enforcement of the Pure Food Law which does not appear on the surface. All these investigations which were in progress or brought to completion during the past year, were conducted in addition to the regular analyses which included many thousand samples. They probably do not represent a period of more than

normal activity in this respect, for new matters and trade practices requiring consideration are constantly demanding attention. The problem is certainly a large one and both time and patience on the part of officials and of the public are necessary if it is to be solved in the best way.

A DISSENTER FROM DARWIN

In the four Lowell lectures by Professor W. Johanssen of Copenhagen on "Primary Conceptions of Heredity," the speaker gave a low estimate of Darwin, referring continually to the mistakes in his hypothesis of selection. He was apparently set but little higher than Hippocrates, save that he knew of the circulation of the blood and could make use of it. In much the same way the speaker treated Galton, acknowledging that he has secured many statistics in work on humans and in botany and has formulated various ratios, which observation with large numbers has set aside. The text of the whole course of lectures was that personal characteristics are not transmitted from ancestors to progeny.

The subject is a technical one and Professor Johanssen did not present all of the links that a popular discussion might require. His general ground is that the traits of individuals are the results of certain combinations of factors in the egg and the sperm, termed gametes and when combined zygotes. The boy resembles his father not on account of his being his father, but because the same kind of gametes and zygotes dominated in his embryo. They are alike because they are similar products.

Galton made many researches with reference to size, but his conclusions that a certain ratio of large or little height, for example, will persist in the progeny has been overset by showing that in beans, for example, the combining of small sizes will not result in the end in a product always of small size.

The lecturer brought to the company two new words, "phenotype," looking alike, and "genotype," acting alike. Many individuals that look alike prove to have very different progeny, while others quite unlike in appearance are found to produce likes. The lecturer illustrated this point by saying that water and alcohol look alike but their effect is very different. Much of the lecturer's argument was in calling attention to chemical matters, and the speaker sought to point his moral with chemical reactions.

Professor Johanssen disposed of some of the terms used by students of heredity. He noted "dominant" characters are often not dominant, that "unit" characters are often complex, and warned his hearers with reference to the loose use of terms, saying that a boy does not inherit his father's taste for tobacco, but imitates it.

"Biotype" is another of the words, which describes the factor whose reactions shall be constant to a given type. But as in chemistry there are different forms to the same combination of elements—water, ice and steam, for example—so there is here what might be termed, "an elasticity," to the biotype. This elasticity, Professor Johanssen explained, is what is responsible for the variations from type forms. In connection with this there was urged the discontinuity of type. The trend at both ends was missing from this portion of the story. The suggestion was that the biotype is capable of so much elasticity that the different ones are able to cover all known forms. This idea is distinctly at variance with the one usually held by naturalists that the varieties in types are probably the remnants of old connecting links. The speaker rules out from the argument the evidence that a museum can adduce from its specimens, using for his illustration here the raindrops on the sidewalk. One might take scattered rain-

drops the specimens in the museum and make from them a story which would be at variance with that of the rain covering the whole sidewalk,—representative of the fullness of variety of Nature.

"Pure lines" is one of the specialties which this speaker brought forward, being so nearly as may be represented those species the zygotes of which are relatively such that the species breed true.

Incidental to the lectures were many references to illustrations, flowers, the lower animals and invertebrates and the like by which the points were illustrated. There were also many references to experimental work, which the speaker said all pointed to the fact that personal characteristics are not transmissible. One of the most interesting series noted was that by Tower of Chicago, who, in experimenting with the Colorado beetle, established some facts. With heat and moisture he changed both the adults and the eggs and young. While the living adults were changed in their markings their young exhibited the normal markings of the species. On the other hand the changes effected in the eggs proved constant. In some of the experiments an intermediate untreated laying of eggs bred true while the treated groups were alike different.

One of the practical outcomes of the study was the expression at the fourth and last lecture that eugenics is established on a false basis. "The individual," he said, "who in the midst of poor surroundings has become a criminal might, under better environment, have made a very fine man."

TESTING PROPELLERS

A CONCLUSION reached as a result of experiments conducted by the department of naval architecture of the Institute after two years of work with the model boat *Froude*, is of great interest. The Technology experimenters assert that propellers are seldom set in the proper place to get the highest efficiency. Professor Cecil H. Peabody says that placing the screw a couple of feet farther astern from the hull will oftentimes give an increase in efficiency of from 10 to 12 per cent.

REINFORCED CONCRETE SCOW

A SCOW to be used as a tender for supplying coal and fresh water to river dredges has recently been built of reinforced concrete for a firm at Baltimore, Md. The vessel is 80 feet long, 22 feet wide and 7 feet deep, the walls being 3 inches thick. Two bulkheads, each three inches thick, extending the full length of the scow, form the water tanks. The scow has a capacity of eighty-seven tons. As an acceptance test, a mass of material weighing over six tons was dumped into the hold, but no signs of failure occurred.

NEW MEMBERS OF THE SOCIETY OF ARTS

AT THE 676th meeting of the Society of Arts held Monday, January 22, the following applicants for membership were presented and elected:

GEN. FRANCIS HENRY APPLETON, 251 Marlborough St., Boston.
E. F. AYER, 141 Milk St., Boston.
WILLIAM SUMNER APPLETON, 8 Park St., Boston.
GEORGE S. BALDWIN, 27 State St., Boston.
ALBERT G. BARBER, 403 Washington St., Boston.
ARTHUR L. COLLIER, 26 Baker Ave., Beverly, Mass.
CHARLES K. CRANE, Dalton, Mass.
HENRY E. DARLING, 15 Dey St., New York, N. Y.
J. WINSOR DAVY, 301 Equitable Bldg., Boston.
CHARLES E. DONLAN, Long Island Hospital, Boston Harbor.
F. A. EUSTIS, 131 State St., Boston.
HERBERT D. FOSS, 11 Linnaeau St., Cambridge.
MORRILL GODDARD, 2 Duane St., New York City.
N. W. JORDAN, 53 State St., Box 2004, Boston.
MRS. FLORENCE A. KEEP, 2251 R St., N. W., Washington, D. C.
JASPER N. KELLER, 50 Oliver St., Boston.
J. FREDERICK MCCLOSKY, Asst. Supt., United Shoe Machinery Co., Beverly, Mass.
J. FRANKLIN MACELWAIN, 39 Chestnut St., Boston.
WILLIAM P. MARSH, 10 Laurel St., Waverly, Mass.
SAMUEL PEACOCK, 725 So. 60th St., Philadelphia, Pa.
W. C. POWERS, 155 Pearl St., Boston.
HENRY H. PROCTOR, 282 Commonwealth Ave., Boston.
CHARLES D. RICE, 112 Canal St., Boston.
CHARLES E. RILEY, 93 Bellevue St., Newton, Mass.
B. ATWOOD ROBINSON, 216 High St., Boston.
THEODORE SCHNEIDER, 280 Dartmouth St., Boston.
CHARLES S. COOK, 24 Winter St., Boston.

THE PRINCIPLE OF RELATIVITY

THE NEW IDEAS OF SPACE AND TIME WHICH HAVE MARKED AN EPOCH IN THE MODERN THEORY OF PHYSICAL PHENOMENA

BY D. F. COMSTOCK

II

In the last article it was necessary to deal with the Principle of Relativity in a general and somewhat vague way. In the present article a more definite treatment will be attempted.

The Principle of Relativity came into existence through the study of "electric systems." By an electric system is meant a combination of electrically charged bodies having any shape and moving in any way. It will be remembered by those who have studied elementary physics that two electric charges of the same sign repel each other, while two charges of opposite sign, attract each other. Any group of charged bodies is, therefore, acted upon by numerous forces throughout its structure. According to the particular structure of the system, these forces may tend to elongate, compress, twist, or deform the system in any way, dependent, as has been said on the particular position of the electric charges and on their magnitude.

Now there are certain fundamental facts which seem to indicate clearly that the atoms of matter are to be considered as electric systems, and consequently the above remarks with regard to electric systems in general apply with force to all considerations respecting the constitution of the atom.

As a matter of fact, the forces above referred to, which must exist throughout any system of electric charges are probably all of much greater importance in atomic phenomena than they would be in the case of any electric system which we could construct in our laboratory, for a reason which may be briefly outlined as follows: When a metal conductor is charged with electricity and, therefore, becomes one example of an electric system in the above sense, the forces due to its charge tend to distort it in one way or another. But in the case of any charge which we could hope to communicate to the conductor in the laboratory, these forces would be so extremely small compared with the rigidity of the metal, that in general there would be no change in shape which could be noticed with ordinary instruments.

We have every reason to believe, however, that the case is very different indeed with an atom considered as an electric system, for as will be remembered by those who have followed the development of modern physics, the atom must be considered as composed largely of minute charged particles called *electrons*. These particles are so much smaller than the atom that the size ratio might well be illustrated as that of a pin head to an office building. We know very little about the actual structure of the atom, very little, that is, of the way in which the contained electrons are arranged within it, but there seems to be good reason for believing that there is *some* definite arrangement and that a number of electrons, together with a certain amount of the even more mysterious "positive electricity," go to make up the thing which we call an atom of matter.

Now the "unoccupied space" within the atom must apparently be very great so that the electrons, held in some sort of equilibrium by the electric forces, must be very far apart compared with their size, and hence an atom considered as an electric system is quite a different thing from the charged conductor in the laboratory; for if all the electric charges on the conductor were doubled, the electric forces would be greatly increased,

but as was indicated above, there would be no appreciable change in shape, whereas,—and this is important,—if we imagine the charges on all the electrons within the atom to be doubled, it is probable that the atom would immediately assume quite a different shape. The principal forces within the atom are electric,—the principal forces of our metal conductor, are not the electric forces we have set up by charging but the so-called "forces of rigidity" which give a solid body its permanent shape.*

Now since we may consider any piece of matter whatever, from the physical point of view, as simply a combination of an enormous number of atoms, we may make the following condensed statement: *A piece of matter is probably a complex electric system, being ultimately far more porous than our senses would lead us to suppose. The volume it occupies, its shape, and its tensile strength are probably in the last analysis determined by the number, magnitude and arrangement of the electric charges which it contains.*†

A further complexity now arises which, however, is very important for all "electric systems," and particularly for the type of system which we have supposed the atom to be, for all the electric forces above discussed are somewhat modified when the electric system is set in motion. This is largely due to two facts, long known in the science of electricity;—first, an electric charge in motion acts like an electric current and, therefore, sets up a magnetic field (*i. e.*, magnetism) around it, and second, an electric charge moving through a magnetic field is acted upon by a force which forces it "sideways." ‡ In the case of the electric current, which the moving charge imitates, these two effects are well known in electrical engineering and are at the foundation of the operation of every electric motor. The magnetic field of a motor is produced through the first effect and the lateral thrust on the wires in this magnetic field, which causes the armature to turn, is the result of the second effect.

An electric system set in motion is therefore acted upon by new electric forces caused by the motion, for each charge on the one hand sets up a magnetic field around it due to its motion, and on the other hand is acted upon by forces due to the fact that it is moving through the magnetic fields of the other moving charges. The shape of the electric system, therefore, will be changed if it is set in motion, almost infinitesimally in the case of the small charges which we put on objects,—but quite appreciably if we look at any piece of matter from the point of view of its ultimate atomic structure and the electric nature of the atom.

The exact nature of the change in shape may be calculated from the above mentioned well-known electrical laws without any further assumption. As a matter of fact it can be shown that the new forces are such that the *whole system tends to contract along the line of motion.* It may also be shown that if any charge is oscillating back and forth in a stationary system, *it will oscillate a little more slowly in the same system moving.*

On grounds of well-established electric theory and without any new fundamental conceptions whatever, we may therefore make the general statement. *Any electric system, when set in motion tends to assume a new state of equilibrium, and if this change be allowed to take place then all effects take place in the changed system in a manner exactly corresponding to the way they did take place before the system was set in motion,* all lengths in the direction of motion being a little shorter, however, and all times a little longer.

Looked at from the present point of view, the ultimate question is,—*Can a piece of matter be considered as an electric system?* We have said that there are

*Since the conductor is made up of atoms, these forces of rigidity are in the last analysis atomic forces, and therefore, also electric, but it will be clear that we are thinking of the metal conductor only in relation to the charge *which we put on*, and not with reference to the charges of electrons within it.

†If this statement is not strictly true, it is at least true in part, for whatever non-electrical forces may later be found to exist, it is almost certain that electrical forces play a large part in the phenomena.

‡That is in a direction perpendicular to its velocity and to the direction of the field.

many reasons for believing it can, many more reasons in fact than can be mentioned in an article of this kind.

Considerable light can be thrown on this question by thinking of the earth as a vast moving system traveling as it does around the sun. Let us see what differences we would notice, if we consider first, the earth stationary in space which is easily thinkable, and second, the earth traveling, as it actually does, around the sun with a speed of about 18 miles a second. In the first case, we would be on a stationary electric system,—in the second case, we are on a rapidly moving electric system. What differences would we notice? A little thought will show that unless we observe other planets and stars we would notice *no difference whatever*, for since *all* our lengths are shortened alike in the direction of motion, and *all* our clocks, for they too are electric systems, run a little slower, the relations, which after all are all that we really observe, would remain exactly the same. If I measured a wire on the stationary earth and then again the same wire after the earth has been set in motion I can only do it with another piece of matter called a yard stick and, as all electric systems act alike, I would get the same result in both cases. That is, if the yard stick went five times into the length of the wire before the earth was set in motion it would go five times into the length of the wire after the earth was set in motion, although both lengths considered from the standpoint of the permanently "stationary" observer are shorter than before.

A like remark applies to all periodic happenings which we desire to time with a watch or clock. A "permanently stationary" observer would say that all such events on the moving earth took place a little slower than on the stationary earth, but if we found that while the earth was stationary, a certain pendulum beat four times a second, that is, beat four times while our clock was beating once, we would find exactly the same relation holding after the earth were set in motion, for our clock as well as the pendulum would then beat slower.

It is very important to realize while thinking of all time and space measurements that all such measurements are ultimately *ratios* and nothing else. This fact we are all inclined to overlook. When we say that a certain event requires just *ten* seconds, we can know the *precise* meaning of the statement only when we refer to the definition of "a second." Now "a second" is defined as $\frac{1}{86400}$ part of the "mean solar day," and the "mean solar day" is the average time that it takes the earth to turn once on its axis with respect to the sun, so that ten seconds is simply $\frac{1}{8640}$ of an "earth turn." If every speed we know were suddenly doubled all time measurement would be exactly the same as now.

Although it would not be wise to enter here into a discussion of the evidence for believing that a piece of matter may be treated as an electric system, it will be well to mention one very striking result which is very closely connected with what we have just been saying. For if the discussion outlined above is true, we should not be able to detect the earth's motion through space by experiments carried out *on the earth*, that is, without appeal to an outside body, whereas, from almost any other point of view than what I might call the electric system one, effects due to the earth's motion through space should be easily detected.*

Now as a matter of fact, numerous, carefully planned experiments have been carried out to detect the earth's motion in space without reference to an outside body and every one of them has given negative results. The presumption is, therefore, strong from this evidence alone, that we are on the right track. *The necessary conclusion seems to be that all physical phenomena obey the same physical laws of which the known electrical laws are as yet the completest expression.*

Now it should be noted carefully that the reasoning which has been outlined above does not involve the fundamental

*We are, of course, referring to the motion of the earth in its orbit, not its daily rotation. This latter is very small compared with the former, and may be neglected.

conceptions of space and time in any new way. The result involves only well-known electrical laws and the assumption as to the ultimate nature of matter.

Besides the lengths and times on a moving system it can be shown that all the inertias change also. They become in a moving system a little greater than in the same system at rest. By inertia is meant, of course, the ordinary mass of a body, the measure of the amount of matter present. We come, therefore, to the conclusion that if a piece of matter can legitimately be considered as an electric system, then, whether a piece of matter is an atom or a planet, it will, when set in motion, have all its times, all its masses and all of its lengths in the direction of the motion changed somewhat, but *all relations* will remain the same as before.

To get the full implication of this, let us recall the definitions of the units of length, mass and time which men legalize and use in the practical world. Briefly indicated the yard is defined as a length of a certain rod kept at Washington; a pound is the weight (closely related to mass) of a certain piece of metal kept at Washington and the second is $\frac{1}{86400}$ part of an average "earth turn" (with respect to the sun). These units obviously are not abstractions but are determined by real objects, viz., a rod, a cylinder of metal and the planet on which we live.

Now from the standpoint of the "permanently stationary" observer, the three units, yard, pound and second, defined as above, are all different on a moving earth than they would be on a stationary earth. Moreover, they would be different still if the earth's speed in its orbit were to become greater than it is now, so that we can legitimately put our former statement into a somewhat more abstract form. *If all matter obeys the general electrical laws which we have experimental reason for believing that it does, then the fundamental units of mass, length and time are all different on a moving system than they are on the same system at rest.*

The magnitude of the changes in the fundamental units due to motion, is not difficult to calculate. As was said in the first article, the changes are far too small to be of what is generally called "practical importance." Their chief bearing is on electrical theory. The following brief table indicates in a general way the magnitudes involved.

Speed in miles per second.	*Decrease in length.*	*Increase in mass.*	*Increase in time of any motion on new moving system.*
1 (Rifle bullet).	A million millionth of one per cent.	Same.	Same.
18 (Earth going around the sun.)	Five ten millionths of one per cent. (within reach of experiment using light rays.)	Same.	Same.
18,000 ("Alpha particle" from radium.)	Half of one per cent.	Same.	Same.
180,000 ("Beta particle from radium.")	Fifty per cent.	One hundred per cent. (measured and accurately verified.)	Same.

Although so extremely small, modern physics knows a number of experimental results which would be noticeably different were it not for these effects, and it therefore has opportunity to verify and study experimentally these fundamental changes.

Of course, it is always possible that some experimental result may turn up which would contradict the general principles here outlined and show that some different, although necessarily similar reasoning must be adopted. This, however, is a general statement which applies to any scientific result and not peculiarly to the present one. As a matter of fact experimental and mathematical research piling up, as it does, year after year has caused the belief to grow steadily that the new ideas are essentially in harmony with reality.

As has been said their chief scientific value is in the domain of fundamental electrical and optical theory where they harmonize much that before was chaotic.

The more or less heated controversy which the "Principle of Relativity" has started is, however, due to its more philosophical aspect. It is more or less generally admitted that the "change in units" above described takes place, but the thinkers who have had most to do with

modern electrical theory maintain that, since a moving observer is totally unable to detect in any way the changes in his system which a stationary observer declares do take place, and since, as can be shown, the moving observer sees exactly the same apparent changes in the units of the stationary observer as the latter sees in his, there is no possible reason for saying that one is "stationary" any more than the other.

This complete symmetry between the states of each observer, because of which *either* observer may be called "stationary" and the other "in motion," renders it impossible, these thinkers say, to talk logically about any length as *the* length or any time as *the* time. *Length and time are relative and depend entirely on the point of view, depend, that is, on the state of motion of the observer who wishes to make measurement.*

The conservative forces of the opposition, which, with rare exceptions, are recruited from those who have given the subject little thought, stoutly maintain that although it is impossible, because of the relativity of motion, to specify the time of one observer as any more entitled to the designation of *the* time than that of any other, still "time is one of our primitive intuitions, and must be thought of as universal and absolute." They would consider the fundamental changes which we have discussed as purely physical effects, like the expanding of a piece of metal by heat, and would consider our inability to tell which observer is "absolutely stationary" as merely a physical limitation due to the peculiar structure of matter and the nature of human activity. They think, therefore, that there is no necessity for the scientist and philosopher to reconsider his fundamental concepts.

As above mentioned, there has been a great deal of discussion on this queston during the last few years but the *a priori* arguments of the opposition are not heard as much as formerly and it is becoming increasingly probable that if the Principle of Relativity is finally discarded it will be through some newly discovered experimental fact and not through these *a priori* arguments as to its essential unreasonableness.

Definition

The "Principle of Relativity" is the name given to a group of conceptions founded on the apparently verified truths that, first, the uniform translatory motion of any system cannot be detected by an observer traveling with the system and making experiments on it alone, and second, the velocity of light is independent of the relative velocity of the source of light and observer. These two statements are more definite and exact, but they are nevertheless equivalent to the general statement that matter in general obeys the "electrical laws" in the sense above described.

The conclusion reached is that space, time and mass are all relative and depend on the motion of the observer, in a certain way definitely expressible by mathematical formulæ.

GROWTH OF ELECTRIC SMELTING

The Department of Mines of the Canadian Government has been investigating the smelting of iron by means of electricity. In 1904 when the investigation began there were only four of these electric furnaces in existence. In 1910 there were 114 furnaces, of which sixty-seven were in operation, eleven not working and thirty-six in course of erection. Of these furnaces thirty were in Germany, twenty-three in France, twelve in Italy, ten in Austria and ten in the United States. Seventy-seven of them were of the arc type, fifty-five were induction furnaces and two a combination of arc and resistance furnaces. A great increase in the output rating of the furnaces is noted, the largest at present in operation having a rated output of 15 metric tons per day.

The new wireless station at the Charlestown Navy Yard, Boston, has a maximum range under favorable conditions of about 3200 miles, thus making it among the most powerful in the world. The aërial poles will each be 170 feet high.

POTASH SOURCES IN THE UNITED STATES

INCREASING DEMAND HAS TURNED ATTENTION TO OUR POSSIBLE RESOURCES—LAKE BEDS SIMILAR IN FORMATION TO POTASH DEPOSITS IN GERMANY

BY G. F. LOUGHLIN

THE recent tariff troubles between the United States and Germany have brought the potash industry to the attention of the public, and stimulated the publication of several articles on the potash industries and the possible potash resources of this country. The data for these articles is largely taken from United States Geological Survey publications, the most recent of which was written by W. C. Phalen, a Technology graduate (S. B. in chemistry '99, M. S. in geology '02).*

Mr. Phalen's paper gives condensed tables of statistics of the potash industry from 1850 to 1910. The figures show a steady decline of domestic potash production from a value of $1,401,533 in 1850, to $104,655 in 1905, since when, practically all the potash used in this country has been imported from Germany. The value of potash salts imported in 1910 was $8,363,623, an increase of 51.45 per cent. over the value in 1905. He also gives statistics of chemical manufactures in the United States dependent on imported potash salts, and gives some mention of their processes of manufacture, including potassium carbonate, caustic potash, alums, cyanides and derived compounds, fertilizers, bleaching materials, dyestuffs and explosives. The remainder of his paper includes a brief review of the occurrence and mining of potash in Germany, and of the known and possible sources in the United States including mineral deposits and the organic sources, wood ashes, beet-sugar molasses, and residues, wool scourings, and potash in seaweeds.

POTASH IN SEAWEED

One most valuable result of the controversy with Germany was the appropriation by Congress of a limited sum for the investigation of the potash resources of this country. The investigations have been undertaken by the United States Department of Agriculture and by the United States Geological Survey. Secretary of Agriculture Wilson has presented the results of his inquiry in his recent annual report. He states that much potash can be recovered from the immense accumulations of sawdust in lumbering regions, and from other sources already mentioned, but that the most promising source at present is found in the large areas of kelp groves or sea algæ along the Pacific coast. These groves are of various areas, some attaining a length of 5 miles and a width of 2 miles. During the past summer about 100 square miles of kelp groves were mapped and studied and many more areas yet remain unmapped. A conservative estimate shows that the kelp which could be gathered from the 100 square miles already surveyed, and without detriment to the permanence of the groves, should yield 1,000,000 tons of chloride of potash annually, worth at least $35,000,000 or about thrice the value of the present importations from Germany.† The value of the kelp is increased by its content of iodine and probably other useful products which are expected to pay in large measure, if not fully, the cost of gathering the kelp and extracting the potash salts. Methods for gathering the kelp have yet to be worked out, but "enough has been

*Phalen, W. C. Potash Salts, their Uses and Occurrence in the United States. U. S. Geol. Survey, Adv. chap. from Min. Resources of U. S. for 1910, 24 pp. Washington, D. C., 1911.

†Quoted in the *Engineering and Mining Journal*, Dec. 9, 1911.

accomplished to show that this country has within its own borders resources to meet the fertilizer requirements of the present, and of a greatly increased use in coming years."

Potash in Rocks and Minerals

No results of the United States Geological Survey's work have yet been made public, notwithstanding various reports of wonderful discoveries announced in the daily press. The Survey's operations have consisted chiefly in prospecting localities where geologic conditions give the most promising hopes of finding natural potash salts—the beds of extinct salt lakes in the arid west. Some private companies also have been prospecting these deposits, while others are experimenting with the extraction of potash from certain minerals.

The ultimate source of potash, as of all the elements, lies in the igneous rocks of the earth—the lavas poured forth by volcanoes, and the far greater masses of the same material which consolidate at depth and become exposed to view only after prolonged erosion of the overlying portions of the earth's crust. These rocks include a number of different chemical compositions the most common of which contain potash in the following amounts: *

Deep-seated rocks.—syenite 4.49 %, granite 4.07%, diorite 2.12%, gabbro .89%. Corresponding surface lavas.—trachyte 5.74%, rhyolite 4.03%, andesite 2.04%, basalt 1.52%.

A few rocks of very rare occurrence contain over 10 per cent. potash; others, of widely distributed occurrence but in masses of very limited size, contain almost none. The percentage in the whole earth's crust, including the igneous rocks and other rocks derived from them, as estimated by Clarke† and others is about 3.00.

These rocks, save certain lavas which cooled rapidly to rockglass, are composed of definite minerals, a few of which contain important amounts of potash. The most common of these minerals are the alkalic feldspars with from 8 to 15 per cent. potash, black mica 6 to 9.3 per cent. and white mica 8 to 10.5 per cent. The rare mineral leucite contains as high as 19.5 per cent., while other common minerals such as the soda-lime feldspars and certain amphiboles contain small amounts.‡

These minerals and also the mineral alunite, a hydrous sulphate of potash and alumina (K_2O 11.4 per cent.) occasionally found in altered rocks, are possible sources of potash, but no process for its extraction from these minerals has yet been put on a commercial basis. Dr. A. S. Cushman, formerly chemist and assistant director of the Office of Public Roads, has taken out a patent for the extraction of potash from rock powders.§ It is also reported that companies have been formed to attempt its extraction from certain unusual rocks composed largely of leucite, in Wyoming, and from vein deposits of alunite near Marysvale, Utah, and at Goldfield, Nevada. At Goldfield, alunite is one of the most abundant minerals in the rich gold deposits.

Natural Concentration of Potash Salts

Wherever rocks are exposed at the earth's surface they are slowly broken up and worn away by the mechanical and chemical action of the atmosphere and of running water. Only the chemical processes are of interest at present. Of the common potash minerals named above, the alkalic feldspar and especially white mica are much more resistant to the chemical attack of the weather than most other rock-forming minerals; but with sufficient time, and under favorable climatic conditions, these minerals are slowly decomposed, the potash passing into solution, leaving a residue of kaolin

* Daly, R. A. Average Chemical Composition of Igneous Rocks. *Proc. Amer. Acad. of Arts and Sci.*, Vol. XLV, No. 7, 1910.

† Clarke, F. W. Bull. U. S. Geol. Survey, No. 419, 1910, pp. 4–9.

‡ Figures taken from F. W. Clarke, op. cit. pp. 257 *et seq.*

§ Published in the *Chem. Engineer*, vol. 5, 1907, p. 21; Bur. Census, Bull. 92, 1908, p. 39.

(china clay) and quartz. The dissolved potash with the materials dissolved from other minerals, comes to the surface in springs, becomes a constituent of river water and is carried eventually to the ocean, or, in arid regions, to some interior sea or salt lake. River waters differ considerably in their dissolved contents, owing to a number of causes, but their average potassium content is not far from the values in the following analyses which are fairly representative * of rivers draining areas of igneous rocks, or other rocks similar to the igneous in composition.

	1	2	3
Carbonate radicle (CO_3)	26.83	28.15	36.25
Sulphate radicle (SO_4)	14.46	12.78	3.19
Chlorine (Cl)	13.83	8.78	1.24
Calcium (Ca)	14.94	17.14	16.22
Magnesium (Mg)	1.80	4.18	3.25
Sodium (Na)	12.79	6.16	3.91
Potassium (K)	4.29	trace	2.25
Silica (SiO_2)	9.69	18.14	33.69
Alumina (Al_2O_3)	1.38	1.34	
Ferric oxide (Fe_2O_3)	1.38	1.34	
	100.00	100.00	100.00
Salinity, parts per million	14.5	170.	61.

1. Moosehead Lake, Maine.
2. Merrimack River, above Concord, New Hampshire.
3. Ottawa River at St. Anne, near the head of Montreal Island.

Glauconite (Greensand)

When this material reaches the ocean the greater part of the carbonate radicle (CO_3) calcium (Ca), and silica (SiO_2) is appropriated by marine animals. Much of the potassium is adsorbed by mud carried by rivers, a part is taken by plants, for example the kelp so abundant along the Pacific coast, and a part perhaps by the mineral glauconite, a hydrous silicate of iron and potassium (K_2O 3.5 to 9 per cent.), which is now being deposited over a wide area in the shallower waters of the sea just beyond the limits of wave and current action. The process of the deposition of glauconite, however, is complicated and it is very probable that the source of its potassium is in fine particles of undecomposed feldspar in the mud,† or in the adsorbed potash just mentioned.

Such accumulations of glauconite, if later elevated above sea level, are of value as fertilizers. The greensand marls of southern New Jersey and Virginia consist of glauconite mixed with phosphate of lime (of similar origin) and other matter, and has been of incalculable value to agriculture in the first-named state;‡ but it has, in recent years been largely supplanted by the more highly concentrated artificial fertilizers.§

Analyses of the New Jersey greensand show from 3.53 to 6.32 per cent. potash and from 1.02 to 3.87 per cent. phosphoric acid. Glauconite is formed in other ways, but not in commercial quantities.

Potassium in Ocean and Salt Lake Waters

These losses of carbonate radicle, calcium, silica, and potassium through the many ages of geologic time have given the salts dissolved in ocean water quite a different chemical character from those dissolved in the average river water, as shown in column 1 below by the mean of 77 analyses of sea water from many localities by W. Dittmar.

	1	2	3	4	5
Chlorine (Cl)	55.292	55.99	65.81	67.30	23.34
Bromine (Br)	.188	trace	2.37	2.72	——
Sul. radicle (SO_4)	7.692	6.57	.31	.24	12.86
Car. radicle (CO_3)	.207	——	trace	trace	23.42
Bor. radicle (B_4O_7)	——	——	——	——	.32
Sodium (Na)	30.593	33.15	11.65	5.50	37.93
Potassium (K)	1.106	1.60	1.85	1.68	1.85
Calcium (Ca)	1.197	.17	4.73	6.64	.04
Magnesium (Mg)	3.725	2.52	13.28	15.92	.10
Silica (SiO_2)	——	——	——	——	.14
	100.000	100.00	100.00	100.00	100.00
Salinity	3.301–3.737%	14.994	19.215	25.998	5.117

1. Mean of 77 analyses of sea water. Clarke op. cit. p. 95.
2. Great Salt Lake, Clarke op. cit. p. 119.
3. Dead Sea, surface water. Clarke op. cit. p. 129.
4. Dead Sea, at depth of 300 meters. Clarke op. cit. p. 129.
5. Mono Lake, Cal. Clarke op. cit. p. 124.

*Selected from F. W. Clarke's Data of Geochemistry, Bull. U. S. Geol. Survey, No. 330, 1908, pp. 61 *et seq.*

†Clarke, F. W. Op. cit. p. 105.

‡Ann. Rept. State Geologist of N. J., 1886.

§Phalen, W. C. Op. cit. p. 18.

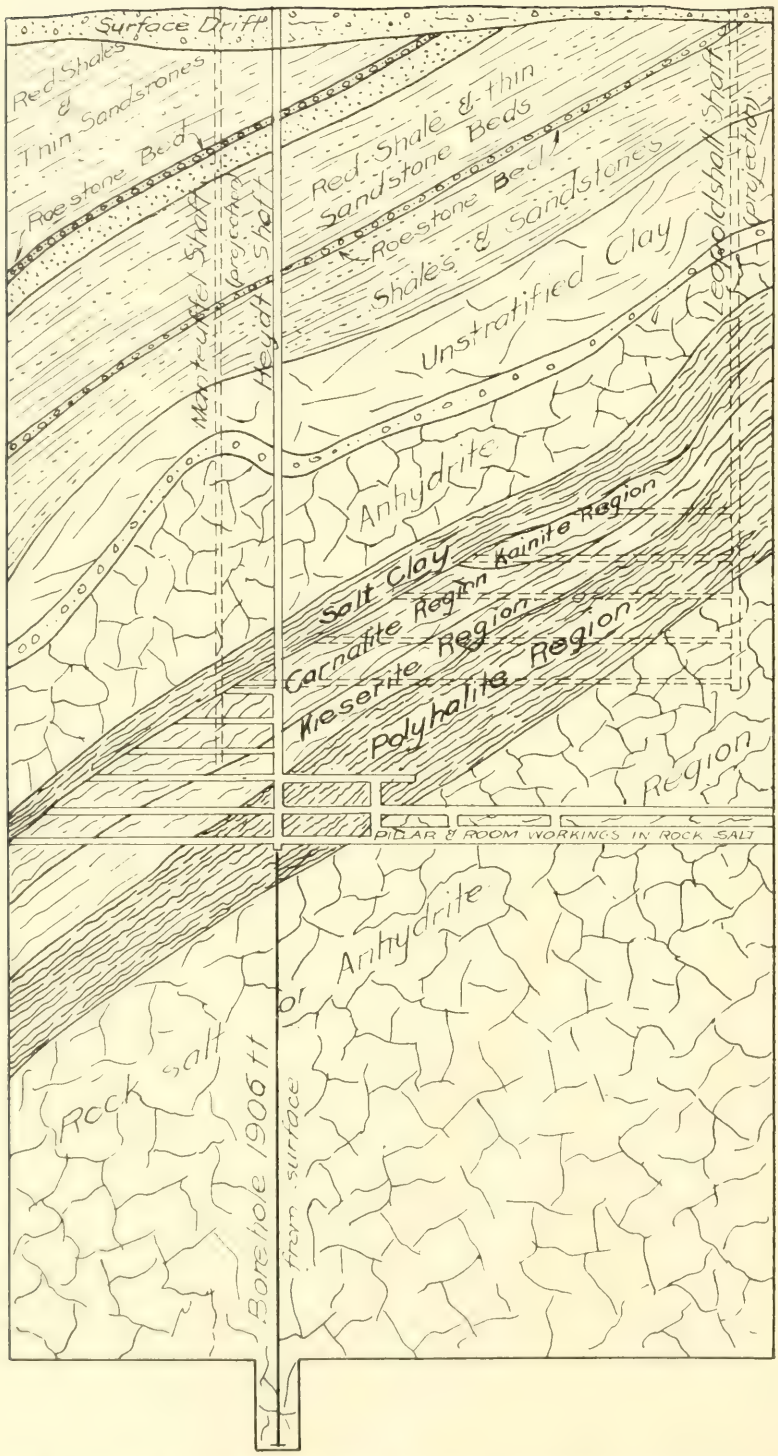


Fig. 1. Section of the Salt Deposits at Stassfurt. (From the Trans. Edinburgh Geol. Soc. V, 1884, p. 111.)

If an arm of the ocean is connected with it by a shallow strait, or if, by any means, a portion of the sea becomes isolated, and in either case the climate is sufficiently arid, evaporation occurs until saturation takes place and salts are deposited in a definite succession. Such conditions have evidently existed in the past, and exist at present, where recent elevations of land have separated the Caspian, Aral, and Dead Seas from the Mediterranean. Kara Boghaz Gulf of the Caspian Sea, connected with it by a shallow passage, is undergoing especially rapid evaporation, and there is a continuous flow of water into it from the main sea, gradually increasing its concentration of dissolved salts. The ratio of salts in the Caspian is not identical with that in the ocean owing to the influx of large rivers, and a closer comparison to ocean salts can be made with those of Great Salt Lake (analysis 2) in Utah, an evaporating lake whose tributary rivers drain for the most part areas of rocks formed by deposition in the ocean but which was never itself a part of an ocean. Its concentration, owing to the arid climate, is about four times that of the ocean.

Comparison of analyses 1 and 2 shows in the latter a total disappearance of CO_3 and an almost total disappearance of Ca from solution, and readily accounts for the oölitic calcium carbonate sand found along the lake's margin. Calcium carbonate is insoluble in a brine of this composition and concentration. Limestones and closely related dolomites ($CaCO_3$.-$MgCO_3$) of this mode of origin are rather widely distributed. Analyses 3 and 4 show successively further concentrations in the Dead Sea at the surface and at a depth of 300 meters. Here most of the sulphate radicle and much of the sodium have been precipitated and are represented by many beds of gypsum ($CaSO_4$.-$2H_2O$) and rock salt (NaCl) in the vicinity. The analysis closely resembles those of bitterns remaining after the artificial extraction of salt from sea water. A little potassium, to judge from the two analyses, has been deposited in some form; but potash salts as a whole are deposited among the very last products of evaporation.

The Stassfurt Deposit

The complete process is illustrated by the occurrence at Stassfurt in Germany (Fig. 1) from which nearly all the present potash supply of the world is mined. The details of the chemistry of deposition are very complicated and not yet fully understood, but the principal stages accord with those of the modern cases above cited. The first deposit, below the section shown in figure 1, was a bituminous limestone; above this came gypsum ($CaSO_4.2H_2O$) and the closely related anhydrite ($CaSO_4$), and next in order rock salt and anhydrite. In artificial evaporation of brines of this type, rock salt begins to appear when the solution has been concentrated to about one tenth its original volume. Above the rock salt came the zones of polyhalite ($2CaSO_4$-$MgSO_4.2H_2O$), kieserite ($MgSO_4H_2O$), carnallite ($KMgCl_36H_2O$) and kainite ($MgSO_4KCl._3H_2O$). The two latter minerals (with other K-Mg minerals of doubtful origin) mark the extreme of evaporation.

Following their deposition, a change in climatic conditions renewed the supply of water, which brought in fine clay with it in suspension and formed the layer of salt clay. Dilution continued until only anhydrite could deposit, when evaporation was resumed giving a second bed of rock salt;* but at this stage another change of conditions again renewed the supply of water which covered the salt series with a considerable thickness of sands and clays (now consolidated to sandstone and shale).

Gypsum and Salt in the United States

Geologic evidences of frequent oscillations in climatic conditions are very abundant and are to be found in this country in rocks of various ages from among the oldest (pre-Cambrian) down to those now in process of formation. The chances, therefore, for the total

* According to some authorities this salt bed was formed by a leaching of underlying beds.

evaporation of an inland sea, as was the case at Stassfurt are very small. Limestone (of this mode of origin) and gypsum formations are widely distributed, and in many places their intercalation with shale and sandy beds is characteristic. Even rock salt deposits, though of less frequent occurrence than gypsum, are not very uncommon, and are mined in Michigan, Ohio, New York, Pennsylvania, Kansas, Louisiana, Texas and a few other states; but in none of these deposits have deposits of potash salts been found. A boring at Goderich, Ontario,* 1517 feet deep, passed through six beds each of alternating limestone-dolomite-anhydrite and rock salt. It is possible that potash salts may have been deposited above some of the salt beds, only to be redissolved when the brine became rediluted. The Stassfurt deposit may owe its preservation to its protection by the impervious shale which was deposited upon it at the beginning of the next redilution stage. It records a most exceptional instance, not only where evaporation was allowed to continue to completion, but also where the highly soluble potash salts were protected from re-solution.

Possible Potash Deposits in the United States

But while the formation of such deposits is to be regarded in general as improbable, a most promising place to prospect for them is in the arid Great Basin region of the western United States (Fig. 2). The complete geologic history of the region is long and complicated, but only the closing stages are of importance here. In rather recent (Tertiary) time the Great Basin was the scene of great volcanic activity which was accompanied, or closely followed, by an elevation of the whole region; but, while elevation as a whole was taking place, the earth's crust became ruptured along many lines of north-south trend and broke into a number of immense blocks, which became tilted and slid past one another, producing the present striking Basin mountain ranges. This rupturing and movement has extended through a long interval and in a few places is evidently still continuing.

The total effect of the movement has been to produce among the range several more or less disconnected valleys, none of which have a low outlet. These valleys fed by streams from neighboring mountains, gave rise to several lakes shown in Figure 2. The two largest of these, Lake Bonneville (of which Great Salt Lake is a remnant) and Lake Lahonton which covered large areas in Utah and Nevada, have been studied by G. K. Gilbert and the late I. C. Russell of the United States Geological Survey. The lakes varied in volume from time to time, and at one period of humid climate Lake Bonneville rose until it stood 1,000 feet above the present surface of Salt Lake and found an outlet northward into the Snake River (Fig. 2); but since that time periods of arid climate have prevailed and the lakes have shrunk by stages, each important stage being marked by wave-cut shore lines along the mountain ranges, until today only the few small scattered remnants shown in Figure 2 remain.

Study of a large scale map of these old lake floors, especially in the Lake Lahonton area, shows that the gradual disappearance of the large lakes must have left more small bodies of water than the few indicated in Figure 2. Some have completely evaporated, and must have deposited their highly soluble potash salts. That the total amount of potash in these deposits is practically unlimited, is readily realized when it is estimated that the relatively insignificant and dilute Mono Lake in California (see Fig. 2 and analysis 5 on p. 47) contains the equivalent of 10,000,000 tons of muriate of potash.† The analysis of Mono Lake water further shows that additional deposits of sodium carbonate and borax, the former now almost wholly imported from Chile, may be expected.

* Merrill, G. P. The non-metallic minerals, Rept. Nat'l Museum, 1899, p. 198.
† Mitchell, G. E. American Potash for America. *Nat'l Geog. Magazine*, April, 1911.

QUATERNARY LAKES OF THE GREAT BASIN

Quaternary Lakes ▨ Boundary of the Great Basin ~·~·

100 75 50 25 0 100 200 300

Scale of Miles

Figure 2

Such deposits may be pure, or may be mixed with silt washed from the adjacent mountains. Their purity, exact location, thicknesses and horizontal extents must be learned by prospecting with the drill. Such is the prospecting now being conducted by the United States Geological Survey, as well as by private interests, with good prospects of success.

Addenda to Foregoing

Shortly after the above article was submitted, two bulletins of the United States Geological Survey were received, giving an account of the past season's progress in the search for potash. Bull. No. 530-A, by Hoyt S. Gale ("The Search for Potash in the United States") tells of operations in the West. A study of the "Red Beds" (a series of red sandstones and shales) in southern Wyoming was first made, since many such formations are accompanied by considerable saline material; but, as analyses showed that there was less potash in spring and well waters from these rocks than in the

average of 33 representative American river and lake waters, it was decided not to pursue these investigations further at present.

The geologic conditions pointing to the possible existence of buried deposits in the Great Basin are next given, largely in a summary of parts of I. C. Russel's monograph on Lake Lahonton. There are two most striking points in this account. The first is the evidence that Lake Lahonton (and also Lake Bonneville) had two periods of high water separated by an intervening period of desiccation even greater than that which exists today. The second explains the burial and absorption of salts by clays deposited in the dry lake basins during rainy seasons, the pure salt grading upward into alternating thin layers of salt and clay and finally giving way entirely to clay. After a study of the geologic conditions the Carson Sink in Nevada was selected for a preliminary test by drilling, and by December 1 a depth of about 320 feet had been reached. A tabulated drill record up to December 1 is given showing that only sand and clay beds have been penetrated. No conclusive results have yet been reached. Similar operations by a private company are to be started in Railroad Valley, 200 miles southeast of Carson Sink in Utah.

Bulletin number 350-A, by W. C. Phalen, describes the search for potash salts in the bitterns from the salt deposits that are now being worked in the eastern United States. Mr. Phalen has visited the different salt-producing districts and taken a large number of samples for analysis. The work of analyzing the samples is now only begun, and but few analyses are given in Mr. Phalen's report. Those of brines from New York and Ohio are not promising, but one from Fairport Harbor, Ohio, of a natural bittern, containing 7.4 grams per liter of potassium chloride, is especially worthy of attention.

ISOLATING THE TYPHOID BACILLUS

While it has been recognized for a number of years that typhoid fever is a water-borne disease, bacteriologists have, with a few notable exceptions, been unable to isolate the germ of the disease—*bacillus typhosus*—from waters that have certainly carried the organism. This failure to find the typhoid microbe has been due to (1) the interval elapsing between the time that the water is infected and when suspicions are aroused as to its dangerous character, and (2) the great difficulty that exists in examining a sufficiently large quantity of water, and of picking out the typhoid bacillus from the numerous other bacteria present. These difficulties have seemed so great to most bacteriologists that they have usually refrained from making a search for the typhoid bacillus itself, and have relied merely on finding the organisms characteristic of sewage pollution and then assuming that in all probability the typhoid germ is, or at least was, present in the offending water.

While great headway has been made in the isolation of typhoid bacilli from the dejecta of sufferers from that disease, there has been no parallel progress in the isolation from water. In the past the isolation of the organisms in question has sometimes been accomplished by filtering a considerable quantity of the suspected water and then growing the bacteria collected on some special culture medium which would result in the colonies of typhoid bacilli being differentiated from the other organisms present. This has been no easy task, and the results have not been satisfactory. Attempts have likewise been made to add to the water such coagulating chemicals as lime and alum, permitting the precipitate to settle out and then examining the enmeshed bacteria. Still other methods have been devised, but none have given good results.

Doctors W. James Wilson and Charles Dickson have, however, recently developed a method of isolating typhoid

THE SOCIETY OF ARTS OF THE MASSACHUSETTS INSTITUTE OF TECHNOLOGY

The Society of Arts was established as a department of the Institute by President Rogers in 1861. It is especially devoted to the general dissemination of scientific knowledge, and it aims to awaken and maintain an interest in the recent advances and practical application of the sciences.

Any person interested in the aims of the Society is eligible to membership.

The annual dues are $3.

RICHARD C. MACLAURIN, President of the Institute.
ISAAC W. LITCHFIELD, Secretary of the Society of Arts.

EXECUTIVE COMMITTEE

ELIHU THOMSON
JAMES P. MUNROE
THE PRESIDENT
THEODORE N. VAIL
CARROLL W. DOTEN
FREDERIC H. FAY
THE SECRETARY

BOARD OF PUBLICATION

D. F. COMSTOCK
SELSKAR M. GUNN
ELLWOOD B. SPEAR
LEWIS E. MOORE

I. W. LITCHFIELD, Editor

bacilli which promises to be of great value. These investigations concentrate the bacteria by evaporating a considerable quantity of water and then making a bacteriological examination of the small amount left, using for this purpose some of the special differentiating media referred to above. Some of their results seem to indicate that this method may come into general use.

It is, of course, necessary that relatively low temperatures be used in evaporating the water, otherwise all bacteria would be killed with the exception of a few spore-bearing bacteria having little or no significance. The temperature used in the experiments of Wilson and Dickson was in no instance above 37° C., and evaporation was hastened by attaching a strong suction to the evaporating chamber. In this way four liters of water can be evaporated almost to dryness in twenty-four hours. To test the apparatus the investigators took 4 liters of water, containing 800,000 normal water bacteria, and added to it 39 typhoid bacilli and 4,100 colon bacilli, the latter being a form common in sewage and one that interferes with isolation of typhoid. This was then evaporated, and typhoid bacilli were successfully recovered from the small residue.

Having obtained satisfactory results with the apparatus, the investigators next proceeded to study the question in more practical ways. An artificial well, made of glazed earthenware pipe, was sunk in the ground, and was left open to the weather conditions of the outside air. Sixty liters of tap water were placed in the well and small quantities of the feces and urine from persons who were known to be secreting typhoid bacilli were added. Samples of the water were then taken every few days, and evaporated and examined as described. The observers were able to isolate typhoid bacilli up to the twenty-fourth day.

This fact has special significance as certain eminent English bacteriologists have maintained that typhoid bacilli were unable to survive in water for more than a week, and that less than a month's storage of a raw river water was apparently absolute protection against typhoid fever. That such statements should be accepted with reserve is evident from the findings of Wilson and Dickson, and it is also evident that the solution of the important question of the viability of typhoid bacilli in water is still an open one and in need of further study and investigation.

S. M. G.

HINTS FROM "THE WORLD OF DREAMS"

DREAMS THE SYMBOLS OF BODILY CONDITIONS—ILL HEALTH CONDUCIVE TO CEREBRAL CONDITIONS SIMILAR TO THOSE OF THE DREAMING BRAIN

BY PERCY G. STILES

Havelock Ellis, a profound student of the nervous system and a writer of exceptional charm, has given us under the title quoted above, a book both recreative and informing. It is scientific in method but none the less artistic. One comes to admire most warmly the insight of the author and his mastery of expression. To the man who has paid some attention to the imagery and emotion of his own dreams, but who has felt himself to be a hopelessly blundering amateur at this pursuit, the luminous suggestions of this skilled interpreter come home with compelling power. He sees signs of order and sequence where he had found only confusion and incoherence. He learns something of his own personality at which he may laugh or wince according to his mood.

One cannot, however, pass final judgment upon himself with a few imperfectly recalled dreams as a basis. If one makes the attempt, as sensitive and introspective souls have done, one may be put to shame by the impression of frivolous interests and unworthy aims which seem to be indicated. The specialist reminds us for our consolation that it is the best of us which sleeps most soundly and that neither dreams nor delirium ought to be viewed as fairly diagnostic of the total self. There is, indeed, an element of contrast between the dominant impulses of waking and of dreaming life, a contrast due, perhaps, on the physiological side to the fatigue of the brain mechanisms most used and the assertion of those to which free play is rarely given. This tendency is calculated to make the dreamer distinctly untrue to himself. It is in less direct and more subtle ways that the content of dreams may be self-revealing.

A marked characteristic of dreaming is the symbolizing or dramatizing of bodily conditions. An organic disturbance which the waking mind would readily refer to its actual seat is presented in the dreaming consciousness as a spectacle external to the observer. Thus, we are told, a palpitating heart is not recognized as such by the sleeper. The impression derived from its labor is set before him as the picture of a horse struggling up a steep hill, a man striving to scale a wall, or some such objective example of strenuous toil. A full bladder which demands relief appears in curious metaphor as a fountain playing or an overflowing cistern. Still more remote from their literal character are the representations of a disordered stomach. These may be translated into scenes of battle, torture and mutilation. Distressful sensations are suggested but they seem to exist for the persons whom the dreamer is watching rather than for him.

Havelock Ellis shows us that such a mental process is not so foreign to our daytime experience as might at first be supposed. We have a preference, sometimes amounting to a frailty, for ascribing our feelings to external causes. The singer who ends his song in a glow of exaltation does not recognize how largely his quickened circulation is the source of his optimism. It seems rather to him that the world is just then particularly benevolent and attractive. The illusion is not undesirable. The man at the banquet, with a small percentage of alcohol at large in his veins, thinks that his friends are more than commonly witty and admirable. He invests them with a glow which has its origin in his own modified cerebration. The mode

of formation of dreams is certainly a telling caricature of such psychology.

It is interesting to note that the sick brain conducts itself in many cases like the dreaming brain. This is obviously true when the patient has hallucinations; it can be discovered also when the disorder is much less in degree. For it is the habit of one who is uncomfortable to be aggrieved at his neighbors. This again is dream reasoning, the transfer to others of something for which one's own state is responsible. The invalid who can wholly avoid it must be a rare character. When discomfort increases, the attendant is regarded as negligent and unsympathetic. When the symptoms abate, he is conceived to have become more thoughtful and kind. How quaintly this approaches the absurdly erroneous thinking of the dreamer! It seems to him that he has nothing to do with the exhibitions of malevolence which are annoying him. Yet all the time they are detachments of himself!

This is not written to diminish sympathy for those who suffer. The odds may be insuperable. But for the man who lays claim to abounding health the moral is clear. He is to look to it that his mind operates as that of a waking man and has not the obliquity of the dreamer's. It is his task rightly to estimate the degree of intrusion of the factors which warp judgment—joy and grief, physical well-being and physical depression. In so far as he succeeds—in so far as he views his fellows and his circumstances at a valuation which does not change with his own condition he is a sane man. In the light of Doctor Ellis's exposition he merits the distinction of being called *awake*.

STORAGE BATTERY ELECTRIFICATION

It is reported in the technical press that the Illinois Central Railroad is to buy three storage battery motor cars, using the Edison storage battery, to experiment with in connection with their suburban service in the city of Chicago. It is stated that these batteries can be charged in about forty minutes with enough electricity for a two-hundred-mile run. If this be true, the field opened for electrification along these lines is extremely attractive, as it will, if successful, enable a railroad company to gradually electrify its system by the substitution of locomotives or cars propelled by the storage battery, for steam units as fast as the latter are worn out.

By this means, the financing of the electrification may be extended over a period of years without requiring any enormous expenditure at one time. The fact is, that the only difficulty at the present time in the way of the electrification of any railroad is the large item of expense involved in the necessity of making the change, provided either trolley or third rail is used, suddenly instead of gradually. Such a sudden change, involving as it does, the practical throwing away of steam equipment before it has outlived its usefulness, involves a financial burden that is most difficult to meet.

The storage battery, if successful, will also solve the question of yard electrification in the very best possible manner. Requiring no overhead or third rail construction, the storage battery locomotive can be grafted onto the present steam systems without any disturbance of equilibrium. With the many new developments constantly coming forward, the conservative attitude on the part of the railroad managers with regard to electrification is to be commended. The public in its desire for electrification should not forget that the expense of experimenting as well as the expense of the final change to electricity, must be borne by the traveling public and those who ship their goods over the railroads.

L. E. M.

LECTURE BEFORE THE SOCIETY

Dr. Charles G. Abbot, director of the Astrophysical Observatory, Smithsonian Institution, Washington, D. C., will deliver an illustrated lecture on "The Sun's Radiation," in Huntington Hall, Tuesday evening, February 20. Public is invited.

SPICES AS FOOD PRESERVATIVES

Food preservation has occupied the attention of the public to a very considerable extent during the past few years and the marked activity of both State and Federal governments tending to do away with the common practice of adding certain chemical substances to food products in order to prevent spoiling, or to hide the use of inferior goods or unsanitary methods of manufacture has met with very general approval. An interesting contribution to this general question of food preservation has recently been made by Conrad Hoffman and Alice C. Evans of the Agricultural Bacteriological Laboratories of the University of Wisconsin.

These observers point out that "sodium benzoate has been of particular interest because some experts maintain that it is not harmful to the human system when used in quantities that will prevent the growth of microörganisms in food, whereas others ascribe injurious properties to it, and strongly condemn its use. However, much of it has been used, especially where an inferior grade of material is utilized, and as yet there is no law preventing its use." With this in mind they have made an investigation of the preserving properties of certain spices which are commonly used, and which have not been criticised as objectionable.

Ginger, black pepper and cayenne pepper failed to prevent the growth of microorganisms, and consequently to retard the spoiling of foods. Nutmeg and allspice were found to delay the growth of such organisms, but only for a very few days, so that these spices, also cannot be considered of practical value as antiseptics. Cinnamon, cloves and mustard, on the other hand, showed very marked powers of restraint over the growth of microbes and are to be considered as valuable preservatives. Cinnamon and mustard are considered particularly valuable, "for they are palatable even when used in proportions that prevent all growth." Cloves when added to foods in a proportion which would prevent growth gave too much of a burning taste.

The active antiseptic constituents of mustard, cinnamon and cloves are the aromatic or essential oils which they contain. Clove buds contain about 15 per cent. of essential oils, the greatest part of which is eugenol, or oil of cloves. Cinnamon gives about 0.5-1 per cent. of essential oils, and about 70 per cent. of this is cinnamic aldehyde which gives cinnamon its characteristic odor. Eugenol is also found in the essential oils of cinnamon. Experiments were made to test out the preserving efficiency of cinnamic aldehyde, and it was discovered that even the smallest portion used—a little over 1-100 of a gram to 100 grams of apple sauce—delayed growth sixty days, and that double this amount prevented growth entirely. These proportions were not sufficient to affect the palatability of the food.

Using organisms that had previously been isolated from spoiled tomato ketchup, the relative efficiency of cinnamic aldehyde, eugenol and benzoic acid was next investigated. It was found that cinnamic aldehyde possessed more marked antiseptic power than either of the other two compounds. Of the three, benzoic acid was by far the least effective.

The investigators sum up their experiments as follows—"In case of cinnamic aldehyde a concentration of two parts per 10,000 was sufficient to inhibit the growth of most organisms, only two out of the nine employed showing growth at this concentration. With eugenol five parts per 10,000 proved insufficient to prevent the growth of all the organisms tried, four out of nine having grown. Benzoic acid, on the other hand, revealed a much weaker antiseptic action than either of the above, eight forms out of nine growing in a concentration equivalent to ten parts per 10,000, and five out of nine in a concentration of twenty parts per 10,000, while three others showed doubtful evidence of growth." In conclusion the authors recommend the use of cinnamon and cloves as against such spices as pepper and ginger, and suggest that the more liberal use

of the two former spices may perhaps remove the necessity of adding sodium benzoate for preserving ketchup,—a practice to which there has been so much objection.

The full paper is to be found in the *Journal of Industrial and Engineering Chemistry*, November, 1911, pp. 835–838.

S. M. G.

"HOLES IN THE AIR"

A POSSIBLE explanation of some of the recent disasters in aviation may be arrived at in the following manner:—

In the first place it must be clearly understood that the planes of an aëroplane must move through the air in order to be sustained by it. It makes no difference whether the aëroplane is stationary so far as the earth is concerned or not so long as the air moves under it. A very familiar example of this is the ordinary kite. When in the air it is stationary so far as the earth is concerned as it is held by the string. The wind blowing underneath it sustains it. The "pull" on the kite-string is a measure of the force needed to pull the kite through the wind. The aëroplane is merely a kite in principle except that, to enable it to move readily from place to place, an engine turning a propeller which revolves in the air is substituted for the kite-string.

Suppose an aëroplane weighing 1,000 pounds, with a 50 horse-power engine to be running at the rate of 30 miles an hour and the air to be moving in a direction exactly opposite to that of the aëroplane at a speed of 30 miles an hour (or 44 feet a second) with respect to the earth. The aëroplane is then stationary so far as the earth is concerned and the engine is exerting power enough to sustain the machine and hold it against the prevailing wind. It is possible to turn an aëroplane through a half-circle and head it in the opposite direction in three seconds. Suppose the aëroplane is now headed in the opposite direction in three seconds. In order to be sustained in the air at the same level with no increase in power consumption for sustention the aëroplane must continue to move with a speed of 30 miles an hour with reference to the air or, in its changed direction, running with the wind, at a speed of 60 miles an hour with reference to the earth.

That is to say, a body in the air but initially at rest with reference to the earth must acquire within three seconds a velocity of 60 miles an hour. Everyone is familiar with the inertia effect by which any object resists having its speed changed. This is a perfectly definite amount under given conditions and can be accurately computed by the methods of mechanics. To change the speed of this aëroplane under the given conditions will require the exertion of 73.4 horse-power. A part of this comes from the air itself blowing on the machine but the greater part comes from the engine—which was only of 50 horse-power to start with. Under these conditions it is evident that it is impossible for the aëroplane to be accelerated quickly enough by the engine without using all the power required for sustention. When the power required for sustention is used for some other purpose the aëroplane falls. Once it has started to fall it will probably be nearly impossible to right the machine and acquire sufficient velocity to sustain it before it strikes the ground. This is an adequate explanation of the "Swiss cheese" sky found on gusty days. The aëroplane must have a sufficient velocity with reference to the air to sustain itself. In a lull between gusts it must increase its velocity very quickly in order to have sufficient speed to be sustained. The inertia of the machine prevents a sufficiently quick change of velocity and the machine drops through what undoubtedly seems to an aviator like a "hole in the air."

L. E. M.

THE Trans-Uruguayan Railway which is now in process of construction will be about 370 miles long. It starts from Colonia opposite Buenos Ayres, Argentina, and runs almost due north of San Luis on the northern frontier where it will be linked with the Brazilian system. The entire line will take some years to complete.

EFFICIENCY IN PUBLIC HEALTH WORK

PAPER READ AT A MEETING OF THE AMERICAN MUNICIPAL LEAGUE BY SELSKAR M. GUNN—ECONOMY AND EFFICIENCY GO HAND IN HAND UNDER PROPER CONDITIONS

Any estimate of what constitutes economy and efficiency in health administration work cannot be regarded as satisfactory until the true functions of a health department have been properly defined. Such an understanding has not yet been attained, although the progress of sanitation in the last few years,—resulting largely from the wonderful discoveries of bacteriology and the remarkable achievements of epidemiology,—is gradually bringing a truer conception of the nature of those conditions which have not imaginary, but real health significance. A study of the annual reports of various health departments of this country reveals great variation—both in the objects pursued and in the detailed methods of attack.

Health authorities are being relieved gradually of the burdens of garbage and refuse collection and disposal, plumbing inspection, poor relief, and general hospital maintenance—matters of slight if any public health significance. Consequently, they are becoming more and more able to devote their whole time and energy to questions of real sanitary import—to the solving of problems which will actually result in the decrease of preventable sickness and in conserving human life and happiness. Again, it is generally conceded that at the present time health departments are usually inadequately financed. New funds are not granted for the furtherance of the work of the department, or if so, to only a limited extent. It is doubtful, however, if the funds now actually at the disposal of the health authorities are being spent with *real* economy.

One of the chief causes of inefficiency and lack of true economy is to be found in the lack of proper knowledge as to the comparative importance of the various branches of work which may be pursued. A health commissioner is confronted with the question of what he ought to do to improve the sanitary status of his community. He has limited funds, and consequently cannot do all that he might wish. "Shall I make a special effort to curb tuberculosis, or devote my resources to improving the milk supply?" "Should meat and food inspection be developed before factory inspection?" Questions similar to those are constantly confronting every modern sanitarian in charge of a city health department, and the decisions that have to be made are not always easy or evident. However, it is only by developing such a sense of proportion that efficient administration can be obtained.

It is natural that health department organization should be far from perfect in most places. Their growth has often been unplanned, and the lack of knowledge in the past has largely prevented an orderly and scientific development. What might have been considered good organization twenty years ago would not be able to stand criticism in the light of modern discovery. We find at the present time that certain lines of activity receive far more attention than their actual importance would warrant. Excessive emphasis on meat and food inspection, and an accompanying neglect of milk supply supervision is a good example of this. The particular hobby of a health commissioner may lead to an unbalanced state of affairs, and is to be particularly guarded against. Again, the special prominence of some problem may lead the health officer to undertake work out of all proportion to the actual needs, and to the detriment of some other part of the service.

An interesting example of the great variation in the activity of health authorities with regard to work of the same character has recently come to my attention and will bear repetition here. The number of samples of milk and cream examined chemically in twenty-seven large cities of the United States varied from 4 to 344 per 10,000 of population, and the number of samples of milk tested bacteriologically in twenty-four of these cities varied from 0.6 to 288 per 10,000 population. (These figures are for the years 1909 and 1910.) While it is improbable .that a standard number of analyses based on the population could be set, it is not unreasonable to maintain that these figures show that the health departments of some cities are devoting too much attention to this work and are allowing other lines of work to be neglected, while other cities are neglecting this work although they may be overemphasizing in other directions. It certainly seems that those cities which are making so many chemical analyses are really going to excess in this particular, and that no added benefit in the form of a purer milk is being obtained for the city on account of this *unusual* activity. In one of the large cities which analyzes a great number of samples, the dairy farm inspection work of the department is practically *nil*, the inspectors having to spend so large a part of their time in the laboratory testing samples. The law of diminishing returns is a real factor in inspection work.

If we could really get at the relative importance of all the activities of a health department, we should be in a position to apportion the necessary funds in a scientific manner, giving due weight to each line of work. The death rate of a city cannot be used as a measure of the efficiency of the health authorities. The fallacy of this method of determining the health status of a community has been conclusively demonstrated. Most careful studies of vital statistics are necessary, and the good derived from some lines of endeavor cannot be demonstrated by any statistical methods yet devised. The remarkable statements of some health officers concerning the health of their city would be amusing if they were not so serious as indicating ignorance on the part of this most important city official. Apparent economy may be attained by an untrained man, but in most cases true economy, combined with efficiency, cannot be had unless the health administration is in the hands of an individual thoroughly trained in the sanitary arts. It cannot be expected that anyone who has not received special training, or who has had merely the few hours of hygiene allotted to the subject in a medical school curriculum, is a proper person to be put in charge of the public health activities of a community. The first essential for any city which is honestly seeking to maintain a health department of real value is to secure the services of a trained sanitarian. There is no alternative in this matter. For small communities which are unable to pay for the services of such an individual, it has been suggested that neighboring communities may combine, and so secure the services of an efficient man as the executive for all.

A comparison of the requirements for employment in public health service in this country with those of England, Germany and other European countries, reveals to us a quite unsatisfactory condition. In the foreign countries special evidence of fitness is essential. The state of New Jersey, in the past few years, has required all persons who desire to enter public health service anywhere in the state to pass an examination, and to obtain a license. By this means many who are unfitted by lack of knowledge and training have been excluded from the service. Other states might well copy this progressive step. Too long have we played with the public health. It is a disgrace that severe epidemics are necessary to bring home the lessons of inefficient service. Nor does the necessity for trained officials end with the appointment of a health officer or commissioner. His subordinates should likewise be subjected to suitable examination. The growth of the Civil Service is a step in the right direction.

Among the common methods used by

some health officers to combat insanitary evils is what I shall term, for want of a better word, the "outburst" method. I refer to transitory outbursts of activity directed at some particular business or condition which is supposed to have a bearing on the public health. Sometimes the bakers or ice cream dealers are subjected to a sudden and severe examination as to the sanitary conditions of their places of business, or maybe the fly nuisance is selected for a special campaign of theoretical extermination. While this method of occasional activity is sometimes the only available one for an undermanned department, and occasional inspection and sampling are better than none at all, yet I venture to remark that eminently better results could be obtained by regular and reasonable inspection. It should always be borne in mind that the strength of inspection lies in frequent *reinspection*. Furthermore, the persons concerned prefer a regular inspection and certification. What health officers need is the co-operation of the public, and particularly of those engaged in industries or affairs which have a bearing on the public health. The educational value of frequent and friendly inspection needs no special argument to any who have been working on the problem of dairy farm inspection.

Real efficiency naturally incorporates in it economy. As has been pointed out by the Bureau of Municipal Research of New York City the question of "whether administration has been economical or wasteful can be determined only by contrasting cost with service results." The investigators of this Bureau have emphasized the proper recording of service results, and especially at times when the budget is being considered. While it is true that it is difficult, and at times impossible, for a health department to demonstrate by means of figures the actual beneficial results of various of its activities on account of the complexity and diversity of conditions which may produce a particular disease, yet in certain lines it is eminently practical. We can see it in the city of Richmond in the reduction of typhoid fever, and in the improvement of the milk supply. The results of efficient service are demonstrated in the annual reports of the chief health officer, Dr. E. C. Levy, whose brilliant work has attracted the attention of all progressive sanitarians in this country. Methods similar to those used in this city should be employed elsewhere. They are essential for *scientific budget* making and should be a great aid in asking the city fathers for more money. Even at the best it takes time to get the needed appropriation, but this time may be considerably shortened by using modern methods to demonstrate the needs.

Accounting methods of health departments as evidenced by the financial statements contained in their annual reports are in need of some standardization if proper use is to be made of them. It is almost impossible for cities to compare their expenses with other similar communities. The Massachusetts Association of Boards of Health some months ago appointed a committee to draw up an outline of a form for use by the local city boards in their annual reports. The form of the financial statement is being carefully considered by this committee as an important part of its work.

In a number of cities bureaus of municipal research are in operation, and are doing constructive work in reorganizing the activities and accounting methods of the health departments. This should have a very beneficial effect if carried on with the proper co-operative spirit, and should assist materially in the preparation of a sensible and clear budget that will interest the citizens and win their support.

In conclusion, it seems to me that in order that we may have health departments both economical and efficient, we must free them from politics with its accompanying uncertainties and strife, and place them in the hands of trained sanitarians who shall understand the relative importance of the different lines of endeavor and who will then be able to disburse an adequate appropriation in such manner that the community will receive the maximum protection at the lowest possible cost.

SCIENCE CONSPECTUS

VOL. II FEBRUARY, 1912 NO. 3

MONSTERS AND THEIR PRODUCTION

NEW LIGHT THROWN ON THE CAUSES OF ABNORMAL CREATIONS—EXPERIMENTAL RESEARCH HINTS AT METHODS OF CONTROL AND PREVENTION

BY CHARLES R. STOCKARD

THE laity wonders at the so-called monstrous appearance of the deformed child or the ill-formed young of lower animals. It seems strange at first sight that any individual could develop in an unusual way, and possess a part differing greatly from the corresponding structures in other members of the species.

The student of development, however, in realizing the intricate and delicately balanced organic mechanism concerned in the formation of the embryo, marvels that the cords of nature are so well attuned. The wonder is that all the processes and complexities of development so often follow one after another in proper order and give rise to that splendidly made organic being, a bird or a man! How countless the chances for deviation, how sensitively the plastic organism responds to the surrounding forces, and yet how frequently the normal goal of development is attained.

What is that normal goal; what is the mean around which the variations play; and what latitude may variations attain? Among the millions of human beings in the world each of us recognizes our individual acquaintances by their facial appearances, no two appear exactly the same. Yet all are men. Facing these countless minor diversities why should one wonder at the occurrence of greater deviations?

Any individual presenting a structure unusual to us is said to be deformed. Each extremity in man generally terminates with five digits; if there be more or less than five the hand is deformed. Children born with two heads are double-headed monsters, but if for hundreds of years the majority of children had been of this type, then we would be single-headed monsters (provided, of course, we existed in our present condition).

The monster is the unusual, it may be entirely unfitted for a worldly existence or it may be as capable of living as its ordinary brothers.

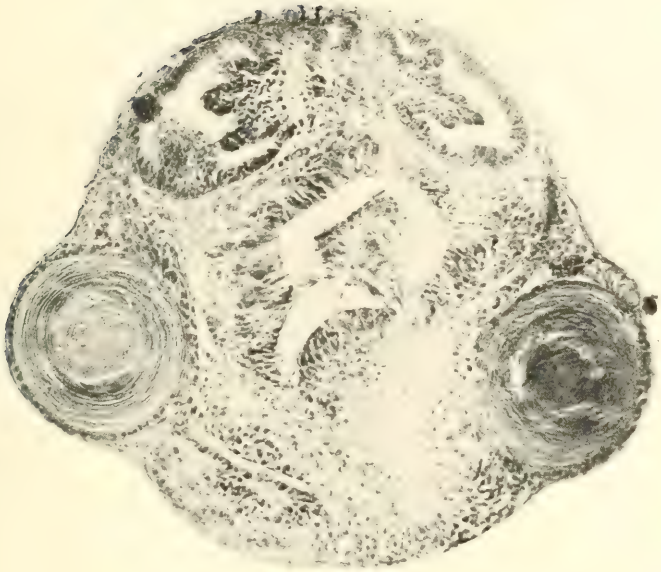
What causes these abnormalities; and is it in any way possible to control or regulate their production?

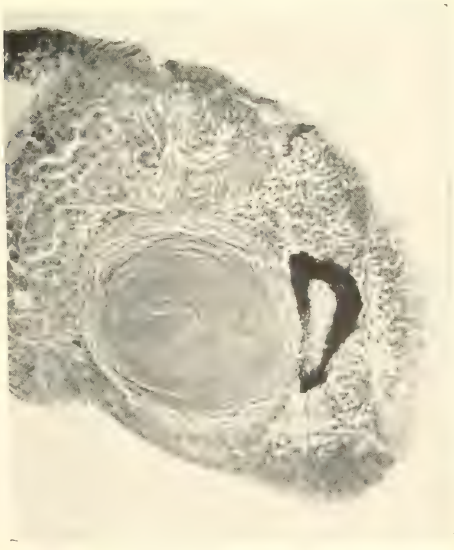
The first clause of this query has excited curiosity as far back as human records exist, and it must be answered before the second part is ready to be attacked. The ancients believed that the gods sent deformed beings as tokens of good or evil. Statues of many of the gods were of monstrous forms and visages.

Unhatched fish embryos which were artificially caused to develop various types of eye abnormalities. The first four illustrate different degrees of the Cyclopean defect. The next two are monophthalmica asymmetrica, the two below are different ages of a three-eyed monster.

The constellations and heavenly bodies were also thought to influence the production of monsters. The appearance of monsters were often interpreted as tokens to the tribe of some fortune or misfortune that would befall them. These mythical ideas gave way to others equally as fanciful and only in recent times have people come to understand or realize the true significance of deformed beings.

The study of embryology and investigations into the normal development of animals enabled the biologists of the last century to appreciate the fact that monstrous forms are merely the result of unusual or abnormal development. Nevertheless, it is surprising to find that even today one of the most absurd of the ancient traditions remains in the widely prevalent idea that "maternal impressions" are the cause of monsters. Many instances are cited of pregnant mothers having been frightened by vicious animals and having later given birth to children resembling in appearance the particular animal, as a result of the men-





Microphotographs showing cross sections of crystalline lenses formed independently of the development of other eye parts when the retina is almost or entirely absent.

tal impression stamped by the mother upon her offspring. These cases are mere coincidents and the resemblance to the animal is highly imaginative.

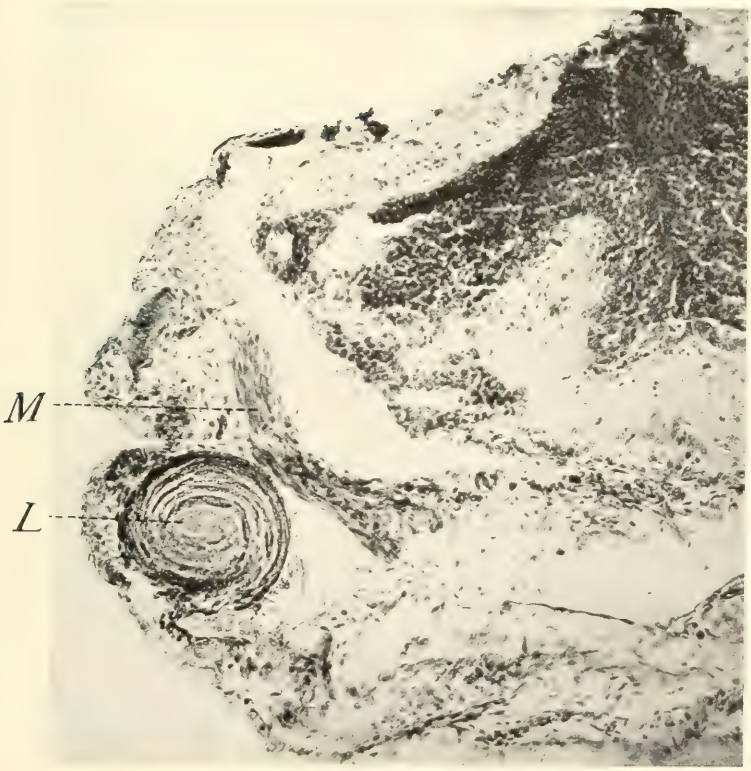
The study of embryology experimental and systematic has shown that all types of monsters are due to one of two causes. Either the individual has sprung from abnormal or diseased germ cells, or the embryo has experienced an unusual and unfavorable environment in which to develop. If the ovum, the maternal germ cell, or the spermatozoon, the paternal germ cell, or both of these cells happen for any reason to have an unusual composition they then give rise to an offspring of unusual form. Such deformities are germinal in their origin and may be handed on to other generations. Accessory fingers and toes, cleft palate, and other defects are of this nature and continue to reappear in a family. In these cases it is the same deformity that continues to occur and by proper selection and mating a peculiar race possessing the given abnormality could be produced. This then becomes a problem of eugenics, but the guarding of the germ cells in order that they may not be affected by unfavorable or diseased environment is an important problem of hygiene, that must be considered and comes before eugenics.

As above stated, the second cause of monstrosities is the development of the embryo in an unusual or unfavorable environment. The influence of such an environment causes the organs and parts of the individual to form in a strange or monstrous fashion. Monsters resulting from such effects would not necessarily produce offspring of their special type should they chance to reach maturity and reproduce. The abnormal conditions of the monster would only be transmitted provided the environment had affected its developing germ cells as well as other parts; and further that the effects on the germ cells had been such as to cause their hereditary qualities to vary in the given direction followed by the body of the deformed individual. An embryo arising from a normal egg and spermatozoon will develop into a perfect individual provided the developmental environment is favorable. The egg of a marine fish develops normally in pure sea water, the egg of a fresh water species develops in fresh water. Cases are extremely rare of marine eggs developing in fresh water and *vice versa*.

If the normal development of the embryo depends upon a given environment either chemical or physical, the experimenter is then enabled to modify the development by modifying the environment. He thus causes an egg to develop into a new or strange being, and by properly adjusting the chemical or physical nature of the developmental environment he is enabled with a certain degree of accuracy to produce a typical structural defect.

Experiments of this kind completely defeat the old ideas and superstitions regarding the causes of abnormal individuals. Further, they hold out a most alluring hope in that by an analysis and control of embryonic development the physician may some day be enabled to prevent the occurrence of deformities in our race. This is not entirely a fanciful speculation. If it is possible to modify development in certain definite ways the next step must logically be the arrangement of a method which will insure a more nearly normal development from formerly diseased or weakened mothers.

I may now briefly cite in a very simple fashion some of the experiments which have gone to show that by modifying the germ cells of either the male or female parent the offspring is also modified. When the male frog is treated with radium or the X-ray its germ cells are affected by the treatment and all the eggs fertilized by such a male develop into abnormal tadpoles. When the female is similarly treated, before she has spawned, all of her eggs develop abnormally even though they are fertilized by an untreated male. When both parents are treated the embryos resulting from their mating are still more abnormal. Thus Bardeen and O. Hertwig have shown with frogs that a defective germ cell causes a defective offspring, and this defect may be derived from either the mother or father.



Microphotographs of cross sections through the eye region of fish embryos. The upper photograph shows an eye on one side of the brain but none on the other. The lower figure shows a perfect crystalline lens on an eyeless side.

The writer has in progress a series of experiments with guinea pigs which now show that if either the father or mother be artificially put into a condition of chronic alcoholism the offspring develop abnormally. The animals are allowed to inhale the fumes of alcohol for six days per week to almost the point of intoxication. When normal females are bred with alcoholic males the fœtus is either aborted before the end of its development, or is born dead, or dies shortly after birth showing various nervous symptoms and dying in convulsions. All of these conditions are due to the effect of the alcohol on the germ cells of the father. When an alcoholic female is mated with a normal male, the same result follows. This is also true when two alcoholic individuals are paired. Thus the abnormal chemical environment induced by the alcohol in the blood of the parent affects its germ cells as well as other tissues of its body and causes a father to beget an abnormal offspring and a mother to produce a defective fœtus.

Abundant statistics show that in the human race the excessive use of alcohol produces effects of very similar nature. I may mention only one or two records out of the great number available to those interested in this subject. Charles Sullivan showed in 1899 that of 600 children born of 120 alcoholic families 335, or 55.8 per cent., died under two years of age. Many of the survivors were epileptic, tuberculous, and generally weak. The percentage of children born dead increased with successive births. While of the first born 33.7 per cent. were dead at birth, the second born 50 per cent., the third born 52.6 per cent., the fourth and fifth born 65.7 per cent., the later births actually averaged 72 per cent. stillborn. Indicating that as the mothers became more and more alcoholic the offspring was less well developed.

Kende studied 46 alcoholic families. Of 21 such families in which both parents were alcoholic 10 were childless, while of 24 children born to the other 11 families 16 died soon after birth and only 3 of the 24 were "entirely" normal. In 18 families, in which only the father drank, 21 children were born; of these only 3 were healthy while the number of abortions and the cases of sterility were very high.

The French observer Nicloux has demonstrated that alcohol passes from the blood of the mother into the tissues of the fœtus. Identical amounts of alcohol were demonstrated in the maternal and fœtal tissues.

Women occasionally give birth to several deformed children by one husband and to several healthy children by a second consort.

These cases of the influence of the abnormal father on the offspring prove that the modified germ cell also modifies the resulting individual. This, of course, we would expect as the germ cells carry within themselves all the hereditary qualities of the race, and these carriers are at base chemical in nature, it follows, therefore, that when they are chemically changed or disturbed their tendencies are modified.

The second cause of abnormalities may now be considered: The influence of the environment on the developing embryo. The embryo is delicately adapted to its normal environment, and, changes in this environment cause modification of various degrees depending directly upon the amount of change from the normal surroundings. The human embryo may be modified by changes in the chemical composition of the mother's blood, due to diseases or intoxications of various kinds or by faulty nutrition from any cause. Interesting examples may be cited among women employed in lead works, where they often become poisoned by the fumes. Women who had formerly produced normally healthy children have during employment in such places produced abnormal offspring which were frequently aborted before term. Constantin Paul long ago found in studying 88 cases of pregnancies among women lead workers that 71 resulted in abortion, premature labor, or still birth, while only 17 children were born alive and of these 5 died within the first year. Several of these women later produced healthy children after leaving this work. Lead not only affects the

Drawings of unhatched fish embryos which show different stages of artificially induced suppression of the eye development. The upper left-hand specimen has no eyes, nevertheless two perfect crystalline lenses (L) have developed.

developing fœtus, but also acts directly upon the germ cells as is shown in the records of men working in lead while their wives were not exposed to the poison. Many of the offspring from such fathers are aborted and the children born are epileptic, feeble-minded or generally defective.

I have been able to experimentally produce a definite type of deformity of certain complex organs or parts by certain treatments of the eggs during various stages of their development. By properly regulating the treatment fish's eggs may be made to develop into embryos, 98 per cent. of which will show eye abnormalities. When one subjects the eggs to a given strength of alcohol for a few hours and then returns these eggs to ordinary clean water a large number of the embryos resulting will exhibit abnormalities of the brain and central nervous system. The eyes and ears are also abnormal. Many embryos show the so-called Cyclopean defect, having one eye in the middle of the face instead

of the usual two lateral eyes, recalling in appearance the ancient Cyclops of Greek mythology. The drawings of fish embryos illustrate the curious eye conditions. With stronger doses the embryos may be caused to develop entirely without eyes, or in other cases one eye forms in its usual position on the side of the head while the other eye is small, defective, or entirely wanting. Monsters of the last type I have called monophthalmica asymmetrica in contra-distinction to the median-eyed or symmetrical Cyclopean forms. These grotesque individuals may be produced by treating eggs with other substances than alcohol, such as ether, chloretone, magnesium, etc., and when the doses are properly adjusted a surprisingly regular result will follow. In one experiment 98 in 100 eggs were caused to form these abnormal individuals. The Cyclopean fish hatch and swim about actively, and may be kept in the aquaria where they feed and grow. The sensitive part, or retina, of the eye is developed in the embryo as a diverticulum from the brain while the crystalline lens folds in from the outer wall or ectodermal layer and associates itself with the retina or optic-cup in such a fashion as to focus images upon its concave surface. Numerous experimenters have held that when the retinal part or sensitive portion of the eye is removed from the early embryo the lens fails to develop, being in such cases useless. This is not true, however, as the Cyclopean and eyeless embryos show that although no eye forms, or ever begins to form, yet a perfectly differentiated crystalline lens may exist. The accompanying illustrations will show this fact. The lens is transparent and is in all respects similar to one that exists within the eye. The embryo, therefore, possesses an innate tendency to form the crystalline lens independently of the associated parts of the eye.

The ears are likewise deformed or absent in fishes developing from eggs treated with alcohol. In some cases only a small portion of one of the semi-circular canals of the ear exists, and in these cases the bony structures which form about the ear to give the bony semi-circular canals fail to develop, and only surround the tiny ear portions which are present. In a few of these embryos the two ear vesicles are excessively large and may unite so that the animal has an ear extending entirely across the back of its head.

All of these experiments, which I have so briefly and I fear so inadequately presented to you, go to demonstrate the extreme plasticity of living stuffs and give some idea of the many dangers which beset the developing individual. Thus it is that one does not wonder at the abnormalities and ill-formed individuals in nature but rather at the vast number of successfully formed beings.

Having shown that development may be disturbed in various directions and that the embryo responds so readily to treatments of different kinds, the question naturally presents itself, may the development of the individual be regulated or guided so as to give a more nearly normal result? Statistics show that in the human race about 23 per cent. of the conceptions of "perfectly normal" mothers result in abortion or abnormal fœtuses. This is truly a high mortality record. One in every four individuals is ordinarily lost before the time of birth. When we include diseased and abnormal mothers the figures are greatly increased.

Many people suffer and ultimately die as the result of congenital defects. Very few indeed are born in a *perfectly* developed condition. This pre-natal destruction must be looked upon as a great disease which sweeps away one quarter of the descendants of healthy parents. No single post-natal disease presents such a frightful death record. Yet little, if anything, is being done to regulate the development of man.

Preventive medicine has made strides in the control of infectious diseases, but it has done scarcely anything towards correcting this great disease of construction in the bodily make-up of the race. To produce a physically vigorous man or an efficient mechanical engine we must build with well-formed parts.

THE BROWNIAN MOVEMENT

THE REMARKABLE PHENOMENON WHICH HAS HELPED TO PROVE THE ATOMIC THEORY AND THROWS NEW LIGHT ON "PERPETUAL MOTION OF THE SECOND KIND"

BY D. F. COMSTOCK

In 1827, the naturalist Brown discovered the fact that minute solid particles in a liquid undergo a ceaseless vibratory motion which is easily visible under a microscope. As a matter of fact the phenomenon is so clearly visible that biologists in examining bacteria have to learn to distinguish between life-motions and the so-called "Brownian movement" which bacteria have in common with all minute solid particles.

For a long time it was supposed that this ceaseless motion was due to some outside cause. It was thought, in fact, that the motion was similar to that of the dust particles which we often see moving back and forth in a beam of sunlight. As time went on however it became clear that this was by no means the case. It has since been definitely shown that the following statements are true:

(1) The agitation is more violent the smaller the particle;

(2) The nature of the particle does not appear to be of any importance;

(3) The motion persists without the slightest abatement when the liquid is left for an indefinite time at constant temperature;

(4) The motion seems to be completely independent of all the outside effects which might be expected to affect it if it were not something very fundamental indeed.

Although it is quite impossible to attribute the motion to any of the disturbing causes which were at one time supposed to produce it, it is nevertheless exactly what mathematical analysis shows is to be expected on the atomic theory of matter. The molecules are, of course, almost infinitesimal in size compared with the particles we are now considering, but the molecules have at ordinary temperatures considerable energy for their size, and their motion must be considered as totally chaotic, so that in bombarding very small particles as they do, it will very rarely happen that the forces of impact are equalized in all directions. The usual result will be that any one particle will be bombarded more vigorously on one side than on the other. A particle, like an insurance company, in order to be permanent amid the losses and gains of individuals, *must be large enough to feel the steadying influence of large averages* and the small particles which we observe are *not* large enough for this. They therefore execute a random movement, first one way and then the other, far slower to be sure than we suppose the individual molecules to move but still amply sufficient to be seen under a microscope.

This supposition, that the Brownian movement is due to molecular heat motion, which is an integral part of the atomic theory immediately suggests a number of ways of verifying this theory itself. A remarkable series of experiments have recently been carried out by Professor Perrin of the University of Paris and have led to the conclusion that the Brownian movement is completely explained as a deduction from molecular mechanics. Professor Perrin succeeded in preparing a solution which contained particles of practically one size only and he made a complete quantitative study of the actions under a number of different conditions, of these particles; their average motion, for example, and their distribution under the pull of gravity. In all cases, not only was the general nature of the phenomena the same as that which can be predicted from general molecular

theory, but the magnitude also was in accordance with it.

There can therefore now be no reasonable doubt that we see in the Brownian movement the direct heat motions produced by the molecules themselves. The motion is not confined to the solid particles which we can readily see with a microscope, but takes place in reality throughout the whole mass of any fluid. The particles serve merely to indicate the motion of the otherwise invisible fluid. We reach therefore the result, surprising from the viewpoint of ordinary life, that *a liquid mass when left to itself does not tend to come to rest.* It only appears to come to rest as regards its larger portions, but its smaller portions remain in visible chaotic motion indefinitely.

To quote Professor Perrin, "Thus comes into evidence, in what is termed a *fluid in equilibrium*, a property eternal and profound. This equilibrium only exists as an average and for large masses; it is a statistical equilibrium. In reality the whole fluid is agitated indefinitely and spontaneously by motions the more violent and rapid the smaller the portion taken into account; the statical notion of equilibrium is completely illusory."

The satisfactory explanation thus rendered of the Brownian movement brings up some interesting considerations respecting what has sometimes been called "perpetual motion of the second kind." This latter should not be confused with "perpetual motion of the first kind," which is popularly known simply as "perpetual motion," and corresponds to the actual *creation of energy.* A perpetual motion machine in the ordinary sense, if it could exist, would be one which would give out energy without taking energy in. The impossibility of the existence of such a machine is perhaps the surest physical law we know. Perpetual motion of the second kind is quite different, but so far it too has been found impossible. The so-called "second law of thermodynamics," states that although heat is a form of energy it cannot be extracted from a hot body unless there be somewhere a difference of temperature or its equivalent. Thus there is heat enough in the ocean to supply more than enough energy for any imaginable human activity, but this heat is all practically at the same intensity (*i. e.*, temperature) and therefore, it is "unavailable energy."

Now those who have thought carefully about these fundamental physical laws have long realized that this second law of thermodynamics, the law which states the unavailability of heat when there is no difference of temperature, is probably only true on a relatively large scale. In other words, it is not true that a body placed in surroundings of constant temperature cannot be set in motion at the expense of this heat. It is only true that a body *large enough to be of practical importance* to us now cannot be so set in motion. A steamship cannot be propelled by means of energy abstracted from the relatively constant-temperature ocean round it, but a far smaller object, namely one of the particles which we observe under the microscope, *is* so propelled for short distances. There is no difference whatever between the one impossibility and the other actuality except that of magnitude.

This does not mean, of course, that the so-called "second law" has been found at last to be "untrue." It means that it is an essentially statistical law and should not be applied to very small portions of matter in the same way as it is to large ones.

By all odds the most important result of Professor Perrin's work on the Brownian movement is the verification it gives of molecular theory. These results alone, many think, would furnish a solid, convincing proof of the general truth of the theory and when they come, as they do, as a supplement to other proofs already obtained, the final probability of its truth can be considered now as little short of certainty.

Professor Perrin's papers on this subject are already classical and it would repay anyone interested to read the little book called, "Brownian Movement and Molecular Reality," translated by F. Soddy, M.A., F.R.S. (London: Taylor & Francis, Red Lion Court, Fleet Street, 1910.)

Slate Group: Mycerinus and His Queen, Fourth Dynasty—Courtesy of *Museum of Fine Arts Bulletin*, Boston

THE DAWN OF CIVILIZATION IN EGYPT

TRACING THE CULTURE OF THE EGYPTIANS NEARLY TO THE STONE AGE—MUMMIES NOT OF ANCIENT ORIGIN—THE SECRET OF THE SPHINX REVEALED

In a course of eight lectures before the Lowell Institute Professor George A. Reisner outlined the dawn of civilization in Egypt and brought down the improvement in the mechanic arts through its most important period, that of the building of the pyramids. The three salient facts that dominated the lectures were that the ancient Egyptians were living in the Stone Age, that the mummification that is popularly taken to be the important accompaniment of burial was but a phase of it in the later years and that the Sphinx is the statue portrait of Chephren and furnished with its lion's body stands to ward the spirits from the tomb of that monarch, the second pyramid. About these facts was woven a most remarkable story of rise and fall of the nation, wastefulness, conservation, change in character of the monarchs and marvelous improvements in the methods of handling stone and other materials.

The first of the lectures was a clear exposition of the kind of evidence and the methods of securing it. The later results have been accomplished by the joint expeditions of the Boston Museum of Fine Arts, and Harvard University and which were along very different lines from the methods of years ago. It was undertaken on the plan of commercial enterprise, the ground inspected, the methods of attack outlined, and when once the work was begun it was followed in every detail by a group of trained specialists. The synchronous operations included excavation, card cataloguing, photography and the mapping of the cemetery. For it should be understood that what is known of the life and habits of the old Egyptians has been preserved through the accompaniments of burial. The man in the spirit world needed the things which he had been accustomed to use in life, and these were buried with him.

With reference to the efficiency of the work Doctor Reisner noted that for the excavation of a cemetery of two hundred and fifty graves, only eight days were necessary and on the ninth day after the photographs were taken of the untouched ground, the work had been finished and the laborers sent elsewhere for other excavations.

In showing the extent of the excavations, Doctor Reisner stated that in view of the flooding of the country by the raising of the Asouan dam, the Government of Egypt had asked that everything of archæological or historical value be taken up. There were one hundred and fifty miles of sand-blown desert, apparently a hopeless task, but it was possible to march an army of pickaxe wielders in lines across the country. A single stroke of the pick was enough to determine whether it was worth while to do more, and in this way the whole area was prospected at the rate of several miles a day. There were, of course, fundamental principles underlying the method, one of them being that remains would be found only in soil that had been overturned, so that if the single stroke showed the natural geological structure, it was useless to spend more time.

The chronology established by Doctor Reisner and his assistants is the following:—Pre-dynastic, B. C. 4500 to 3300; first and second dynasties, B. C. 3300 to 3000; Old Empire, B. C. 3000 to 2400; and Middle Empire, B. C. 2400 to 1600. The New Empire then ensued till about B. C. 1200, then the Egyptian Renaissance, and from B. C. 663 down was the Persian Period. This chronology does not reach such enormous antiquity as have some other computations of the past.

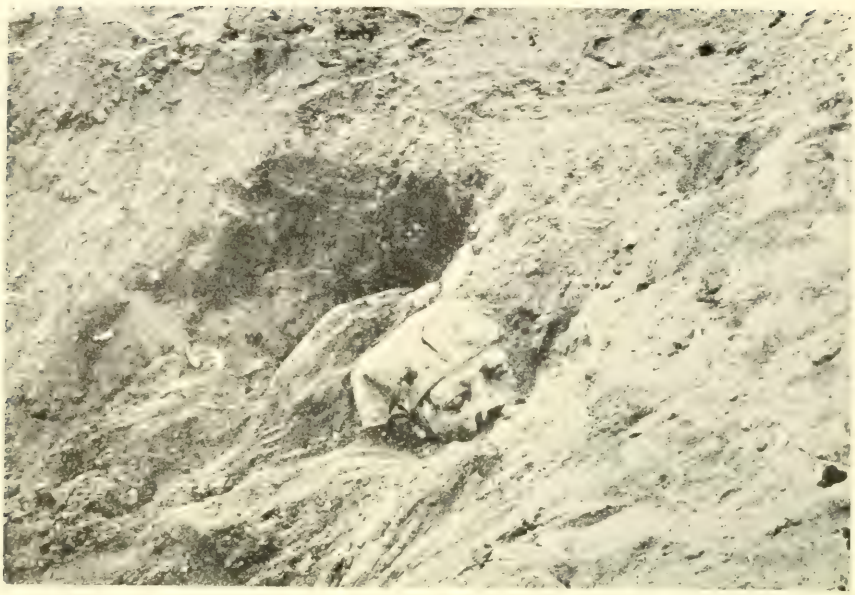
Valley Temple of Mycerinus in Process of Excavation. Pyramid of Khufu (Cheops) Beyond—Courtesy of *Museum of Fine Arts Bulletin,* Boston

An interesting portion of the second lecture was the outlining of the basis on which this chronology rests. There is a fixed date, that of Alexander in B. C. 332, and back of that about thirty years an Egyptian priest, Manetho, made a list of the kings of Egypt. Some of his figures are wrong, much of his material is as yet unidentified, but much remains good in the light of other evidence. There is a papyrus in Turin written apparently in the New Empire on the back of which some one has placed a list of the kings including the mythical ones. The list seems to be accurate, but there are important breaks in it of four or five hundred years. Then there is the Palermo stone, resting in the museum of that city, but carried to Sicily, no one knows how, perhaps as ballast. This is the annual record of the height of the Nile, which in an interesting manner identifies the year by the action of some king. Then there are the inscriptions in the tombs.

In his second lecture Doctor Reisner took up the chronology and race mixtures.

"It is not the question at the moment which is the more ancient," said the lecturer, "but it is true that the Egyptian relics have been much better preserved. In Egypt there was a people whose whole life is now known to man and in its study it is possible to trace the culture back to a time that was pretty close to the Stone Age."

The speaker said that the dates presented by him are less distant by two or three thousand years than those given by some writers in published works, but he believes that his figures are founded on valid authority.



First View of Head of Alabaster Statue of Mycerinus—Courtesy of *Museum of Fine Arts Bulletin*, Boston

As to the people the sculpture indicates clearly distinct immigrant racial types, Negro, Berber, Arab, Philistine and Asiatic. Skulls found have been restored to the semblance of the living man, and from the whole investigation it would appear that with the native Egyptian stock two races were mingled in ancient days; in the north, the Semitic stock was mixed with Berber and Libyan immigrants, while in the south it was the original Semitic mixed with Negro. It was the northern mixture that developed the country and built the splendid monuments and cities. In the south the people have done nothing and are now about where they were in the pre-dynastic days.

The illustrations that Doctor Reisner presented at his third lecture showed the actual material from which this ancient history has been reclaimed and roughly the time may be divided into the Stone Age when the metals were practically unknown, the middle pre-dynastic, when traces of copper are to be found and then the later period when copper was used for the heavier articles such as effective weapons. Certain kinds of pottery or stone ornaments belong infallibly to certain periods.

The Egyptian Stone Age man was weaving baskets and cloth, dyeing his cloth, tanning, making pottery by hand and decorating with crude, yet unmistakable representations of the animals and objects about him. He could cultivate at least one sort of grain, barley, for the dissection of well-preserved stomachs has presented the grain undigested. It is also true that the whole country was culturally a unit, a fact abundantly proven by the universal distribution of articles, like stone objects, whose original locality can be proved by the parent ledges. And again some of the most interesting objects of the decorative art were ships of weird and wavy pattern, which their vases have preserved. It is thus unquestioned that the Nile was in the earliest days used for trade and articles made in few places had universal distribution.

As one of the important matters in which the people are generally mistaken in their notion, Doctor Reisner called attention to the peculiar posture in which the ancient men along the Nile buried their dead. The body was doubled up with the knees near the chin and the hands before the face. The head was usually

First View of the Slate Group of Mycerinus and His Queen—Courtesy of *Museum of Fine Arts Bulletin,* Boston

towards the south. The mummy, which everyone associates with Egyptian burial, is, comparatively speaking, a modern innovation, although the earlier kings were indeed mummified. Much was told about the plundering of graves, which has been done in all ages for the valuables buried with the dead.

The progress of the country was admirably shown by the mineral contents of the graves which serves to give an additional measure of their antiquity. In the earliest tombs galena and an oxide of iron, used for a face paint, were found.

Then in the next period appear some manufactures of gold or copper and in the last of the pre-dynastic periods heavy items, weapons first, because more necessary, characterize the findings. The invention of the needle was another of the interesting stories, illustrated by pictures of the specimens themselves. The awl was used for five or six hundred years in ancient Egypt till the first crude needles were made of copper spindles with the top bent to one side making an eye, and centuries afterwards it occurred to someone to drill an eye through the spindle itself.

Doctor Reisner stoutly defends his neolithic Egyptians against the claims that they were cannibals, showing first that but few instances in the thousands of graves examined, perhaps one grave in five thousand, afforded the evidences that had been brought forward in support of the assertion that they ate their fellowmen. Some joints apparently gnawed were shown by the speaker to bear the marks of predatory beetles which attacked the bone for its enclosure of marrow.

"We have thus seen," said the lecturer, "that the Egyptians grew from savages to learn gradually the arts of metal working; they became prosperous and with prosperity came the struggle for wealth. The effect of this was to divide them into two great factions, one in lower Egypt and the other in upper, and for one hundred years before the first dynasty there was a constant struggle for control. These factions were united by King Menes."

Something of the political history of the Egyptians showed how when there

Upper Part of Slate Group: Mycerinus and His Queen, Fourth Dynasty—Courtesy of *Museum of Fine Arts Bulletin,* Boston

was prosperity, there came union between the different tribes and the whole of Egypt came under the rule of a single sovereign. The holding of the wealth in the hands of a single family resulted in the expenditure of the surplus in great public works which took the form of tombs of kings, etc., enormously costly even with slave labor, and in Egypt there were alternate periods of financial depression and wealth. This is shown in the tombs, for the implements attending the interment in the midst of a panic in Egypt were inferior in quality and number. The graves thus tell after many centuries much of the financial story of the country.

There were many interesting inventions, for example, the mechanical stone pot-borer. First there is in the tombs an inferior quality of clay vases, these improve and later when it was possible the first art declined in favor of machine-made stone vases. The older clay vessels were reserved for religious purposes and occur in the graves with the others. Later better pottery vases replaced the stone ones, these being the ups and downs of the arts, and Doctor Reisner expressed the opinion that no art is ever lost until there is a better one ready to take its place.

Much of the earlier story had to do with the construction of houses. Information about this is conveyed by the tombs which are of the same type. It was a mud-brick architecture with wooden rafters to support the roof. Later the lintel and the arch were used, the latter being one made by corbelling out the bricks till they met, limited to what could be held up by the hands till the key was placed, while the obliquely-laid barrel arch was known to these people. This could be made without the need of a form to hold it while under construction.

Of the ancient Egyptian architecture

Doctor Reisner presents the same idea that other speakers have brought forward in discussing the Greek architecture, that the later work of the country merely followed in some other material the forms of the earlier, cruder material. The original building of the Egyptians was with a mud brick. The people never lived in caves, as has been asserted by some others who seek to trace the architecture to such an origin.

And somewhere in here there came the invention of letters.

There was outlined how culture spread among the people. While it was true that the kings reserved the best workmen for their own edifices, still there were slack times, when the stone masons and sculptors went home while others sought other employ, so gradually it was possible for minor princes and officers to secure excellent art.

The answer to the riddle of the Sphinx was the most striking climax of Doctor Reisner's lectures, the unfolding of the remarkable work of the Boston-Harvard expeditions in determining what the Sphinx really is. It is a portrait of Chephren, the builder of the second pyramid, mounted in the usual way on the body of a lion to ward away the evil spirits from the tomb. This discovery came about in a perfectly logical manner. Doctor Reisner set deliberately at work to unearth for the second pyramid what experience had shown should be somewhere, a valley temple, lower than the pyramid and connected with it by means of passages. This was found by excavation and in the end, from its position the real secret of the Sphinx was unravelled. When the fact was discovered it was fairly easy to verify it by comparisons with other portraits.

Already at the third pyramid the same kind of investigations had been carried forward and its relation to Mycerinus established. It proved to have at its base what was sought with the advanced knowledge of Egyptian customs, the temple of the king who erected the pyramid. From this it is customary to have a gallery extending down hill to a lower temple. These items were found, but not until a sixth dynasty temple, covering the original one of the fourth dynasty, was opened and removed. The outlines of the two temples were established and in excavating the splendid statues of Mycerinus and his queen were discovered, the alabaster statue of the king and a series of slate triads, three figures to a panel.

The story turned largely about Mycerinus, the builder of the third of the pyramids in the great group, and his wife, whose statues recently excavated from his temple, form a showing in the Boston Museum of Fine Arts which is declared to be incomparable and priceless. The wonderful alabaster head in the same department of the Museum is that of his son.

These monuments present a faithful picture of Egyptian art, a picture that is not to be duplicated in the case of any other nation of antiquity. The arts reached the finest stage, reliefs, statues, magnificent buildings, and after the sixth dynasty it may be said that the Egyptians learned nothing more excepting the making of glass. The time has been termed the Pyramid Age, in which there were erected these enormous and beautiful temples and tombs.

Household processes like weaving, domestic arts like harping and singing, the wine press, hunting, shipping on the Nile, fishing and netting birds, the agricultural processes, plowing, reaping, threshing, and trade operations of weighing and storing—all are shown. From the monuments the life of the people is made known. The tombs give the relics on which can be based the knowledge of durable productions, vases, pottery and other manufactures, while the tombs themselves afford a good working knowledge of Egyptian architecture.

The most striking exposition of the whole series of lectures from the mechanical point of view was the development of the art of masonry almost within a single generation at the time of the building of the pyramids. Before then the work had been of mud-brick and of stone in imitation of this, but now there came into existence the extraordinary ability to

cut, handle and lay stone that has hardly had its parallel in all mechanics.

Important side issues of history, the development of painting and of sculpture formed an interesting framework within which this technical knowledge was set.

THE BOSTON SUBWAY

The Cambridge Subway soon to be opened, brings up the question of the general plan of subways which is being developed in the city of Boston. The situation in the city of Boston is peculiar because if the business district be considered at the center of the wheel, the territory which must be reached from this center is nearly three fourths of a complete circle. It is manifestly out of the question to build subways or elevated railways to each one of the outlying suburbs on account of the great cost. The general plan being followed, then, is to build two combination subway and elevated systems which cross each other at right angles in the central portion of the city. The one running north and south will extend when completed from Malden on the north to Forest Hills on the south. At the various stations along this line, surface cars come in and transfer their passengers to the elevated. By this means the surface car traffic is to a large extent kept in the outlying districts where the congestion of streets is a minimum, and passengers are transferred from the surface cars to the elevated system which then brings them in to their destination.

The other line being developed extends from Cambridge on the west under Beacon Hill at present as far as a new station built underneath the present Park Street Station. Ultimately this is to be extended down Winter and Summer Streets, past the South Station and thence in a southerly direction to Andrew Square in South Boston. When this whole scheme is completed, surface cars will be collected principally at Harvard Square from Cambridge and the suburbs in that direction and at Andrew Square from Dorchester and South Boston.

The terminal station at Park Street is so built that when the tunnel is completed, it will become a way station instead of a terminal without any structural changes. At Harvard Square and at Park Street, the stairways are such that the transfer from surface cars to the subway and *vice versa* is made without the use of any transfer checks, and the platforms are so arranged that in any given passageway people can move in only one direction. There are also separate loading and unloading platforms for the subway trains which tend, of course, toward freedom of movement, as people leaving and entering trains do not meet. At Harvard Square there are also loading and unloading platforms for surface cars for the same reason. The whole arrangement is part of a very carefully worked out plan for accelerating the movement of traffic. For instance, the present running time of surface cars from Harvard Square to Park Street is twenty-three minutes. The running time of the subway trains will be between seven and eight minutes. When this subway is completed to South Boston, it will be seen that ready means will be afforded to transfer to and from the old Tremont Street Subway as well as to and from the Washington Street Tunnel. It will also give better access to the South Station than has heretofore been practicable.

L. E. M.

LARGEST OIL PROPELLED SHIP

The *Toiler*, an oil engine ship, 248 feet long and drawing 14 feet loaded, is said to be the largest vessel afloat driven by oil. This ship has but recently entered the Great Lakes for use by the Anglo-Saxon Petroleum Company. She has twin screws driven by two 4-cylinder 180 horse power reversible Diesel oil engines. The machinery weighs 60 tons less than equivalent steam equipment. The oil is carried in a double bottom where water ballast is usually carried. The use of oil instead of coal effects a saving of 120 tons. The German battleship *Goeben* is now being built which it is said will have the central shaft driven by a 12,000 horse power Diesel engine.

VENTILATION OF SLEEPING CARS

CONDITIONS OF COMFORT IN PULLMANS AND PUBLIC BUILDINGS IMPROVING, BUT THE PROBLEM OF REGULATING HUMIDITY NOT YET SOLVED

BY JOHN F. NORTON

In spite of the luxuries of the modern sleeping car, most of us have spent many uncomfortable hours in traveling. This discomfort is more marked during the winter when the doors and windows of the car are kept tightly closed than during the summer when we can sit in a draught of air blowing through a window screen. Further, the discomfort is increased whenever the train stops, and if we get off to get a breath of air, upon returning we are forcibly impressed with the "close" odor in the car, which only disappears after the train has been going for some minutes. Again, we probably spend the most uncomfortable hours in a berth closed by green curtains which seem to shut out what little air we think there may be in the aisle. We go to bed over a hot steam pipe, and if we are fortunate enough to finally get to sleep, we are only too liable to wake up feeling a need for more blankets. If we are obliged to take a 3 a. m. train, and consequently must spend several hours in a car standing in a station, our discomfort is still greater. Some of us always arrive at the end of our journey, if not with a headache, at least with a very dull feeling. We blame the ventilation of the sleeping car for all the discomfort and ill effects of traveling.

Let us first consider the conditions which cause us to feel comfortable or uncomfortable. The air we breathe is a mixture of gases. Nearly four fifths is an inactive gas, nitrogen; about one fifth is oxygen, and the rest is carbon dioxide, moisture and some rare gases. The important constituents for us to consider are oxygen, carbon dioxide and moisture. Whenever we burn coal, wood or gas the carbon in the fuel unites with the oxygen in the air to form carbon dioxide. When the amount of oxygen has decreased beyond a definite value the fuel refuses to burn. For instance a candle goes out when the per cent. of oxygen in the air is 16 per cent. or less. Now respiration is a process of a similar nature; we breathe in oxygen and exhale carbon dioxide. Outdoor air contains about 20.81 per cent. of oxygen and .04 per cent. of carbon dioxide, while in expired air the oxygen has been decreased to about 16 per cent. and the carbon dioxide increased to 4.38 per cent.* Thus we are continually using up the supply of oxygen and replacing it by carbon dioxide. Expired air immediately mixes with the air in a room and this in turn is being replaced by fresh outdoor air, so the actual amount of carbon dioxide in a room only very slowly increases, even with all the doors and windows closed. It is interesting to note that we can breathe in air which contains less oxygen than is required for a candle to burn.

At one time it was thought that the carbon dioxide with which we contaminate the air was responsible for the effects produced by bad air, but even in a "stuffy" room the amount rarely exceeds .5 per cent., while many times this amount is required to produce any injury to the human system. We do, however, still use the amount of carbon dioxide as an index of the purity of the air, not because it is itself harmful, but because it shows us whether we are getting fresh air or are using the same air over and over again. Furthermore, since we know the amount of carbon dioxide in pure air, and the amount exhaled by a normal person in an hour, about 0.6 cubic feet for an adult man, we can calculate the amount of fresh air which is being supplied, and thus

* Foster, quoted by Soper. "Air and Ventilation in Subways." Wiley & Sons, 1908.

obtain an idea of the efficiency of the ventilation.

Another idea as to the cause of discomfort in a close room is as follows. A variety of substances is given off from the body both in the breath and in the perspiration. The amount of these substances is really very small, but as some of them have very marked odors they are readily detected, particularly when allowed to accumulate in a room. It was believed for some time that these had poisonous properties and were the cause of nausea and headaches experienced in a crowded room. From this arose the term "crowd poisoning." Some years ago it was shown by experiments on animals * that these substances were not poisonous and so we have had to give up the idea of "crowd poisoning."

If discomfort is not due to any substances which are given off from the body either in expired air or in perspiration, how, then, can we account for it? At the present time the cause is generally considered to be due to the physical conditions of the atmosphere, and the factors which we must study are temperature, humidity and motion.† These factors affect the rate of removal of heat from our bodies, and it is this heat which makes us feel comfortable or uncomfortable, and causes headaches and nausea. Now, heat is removed from the body in three ways: first, by evaporation of moisture, for we know that when a liquid changes to a vapor, heat is absorbed; second, by conduction, just as heat is transmitted from the hot to the cold part of a piece of iron; and third, by radiation through the ether. If the air is dry evaporation is rapid and consequently heat is removed faster than when the air is moist. Furthermore, heat radiation takes place more rapidly in dry than in moist air. On the other hand, since moist air is a better conductor of heat than dry air, the greater the amount of moisture the more rapidly is heat removed from the body in this way.

In order to make this discussion concrete let us take a few examples and apply these physical principles. Suppose that the temperature is 95° Fahrenheit and the humidity, that is, the ratio of the amount of moisture in the air at a given temperature to the maximum amount which the air will hold at that temperature, is 90 per cent. Under these conditions of high temperature and high humidity most of us are uncomfortable and we describe our sensation as "oppressive." The amount of heat leaving the body by means of evaporation of moisture is very small because the air already contains nearly as much as it can, and what moisture does evaporate immediately saturates the air surrounding the body and prevents any further evaporation. If the air is in motion this condition is somewhat remedied because the saturated air is being constantly carried away and its place is being taken by fresh unsaturated air which can take up a little moisture. The effect of this on our comfort is familiar, for we are all aware of the pleasure of even a slight breeze on a hot, muggy day.

The amount of heat removed from the body under these conditions due to the heat conductivity of the air is also small; for, although the actual conductivity is comparatively high, this is counteracted by the high temperature, because the interchange of heat between two bodies takes place more slowly when the difference in temperature is small than when it is large. In this case the difference is only about three degrees. The heat removed by radiation is also small, for, as stated above, radiation is diminished by the presence of moisture.

The result of all these effects is to prevent the escape of heat from the body, with the consequent uncomfortable feeling, which is of the same kind, although of a much less degree, as that given by a sunstroke.

Suppose instead of having a high we have a low temperature, for instance, 15°; but we also have high humidity. At this temperature air will hold only about one twentieth as much moisture as at the higher temperature. Consequently the

* Formánek. Archiv für Hygiene, 1900, 38, p. 1.
† Hill, quoted by Gulick, *Science*, 1911, 33, p. 327.

amount of moisture evaporated even at a low relative humidity will be small, and at the high humidity which we are considering, the loss of heat in this manner will be very small indeed, and moisture will remain on the surface of the body causing us to feel chilly. Loss by radiation will also play a less prominent part under these conditions. The chilly feeling will be further increased by the comparatively rapid loss of heat by conductivity due to the large difference in temperature between the air and the body, and to the high humidity. If the air is in motion, we are much more uncomfortable than when it is still, for as before, this tends to increase the loss of heat, which we wish to prevent under the given conditions.

From the above discussion it is evident that in order to feel comfortable at various temperatures we must have comparatively low humidity. However, if we decrease the humidity too much we again feel uncomfortable, and it is this condition which we find all too frequently in houses, public buildings and sleeping cars. Indoors, most of us prefer a temperature of 68° to 70° and a humidity of 60 to 70 per cent. If the air is drier than this we raise the temperature in order to be warm and very soon this higher temperature has its effect by producing a sleepy feeling. One of the most noticeable differences between outdoor and indoor air is that of motion. The air in a room, unless the ventilation is of the best, is in a more or less stagnant condition, and heat, moisture and other products of respiration are carried off very slowly, while outdoors we are continually being supplied with fresh air, even when there is little noticeable breeze.

To sum up, then, in order to feel comfortable the heat given off from our body must be carried away from us at the proper rate, and this rate is dependent on the atmospheric conditions of temperature, humidity and motion. Let us see to what extent a proper adjustment of these conditions is aimed at and obtained in the sleeping car.

The older types of car, some of which are still in use, are ventilated simply by opening the deck windows in the top of the car. It is surprising that this method is as efficient as tests have shown it to be, particularly when the car is moving at a high speed. But the ventilation is not evenly distributed, and drafts are created. The recently built cars all have some kind of forced ventilation. The type of ventilator in most general use on Pullman sleepers is known as the Garland ventilator.* This works on the principle of the aspirator or injector, which is to draw the air out of the car by maintaining a suction. The motion of the train causes air to enter a duct located on the top of the car, from which it passes out at the side. In this duct is an opening connected with the inside of the car, and as the air rushes past this opening a suction is created which draws air out of the car. It is claimed that this ventilator will draw 18,000 cubic feet of air per hour, and as each car is equipped with ten ventilators this gives a total of 180,000 cubic feet, or enough to completely change the air in the car every three or four minutes. No inlets are provided for this large volume of air, and, consequently, it must enter around the doors and windows, which even in the best built cars are not air tight. Cars ventilated in this way are heated directly by contact with steam or hot water pipes.

A system based on another principle is in use on the Pennsylvania railroad, and was developed after some years of experiment.† Here the heating and ventilating are combined. Outside air enters hoods placed at diagonal corners of the car, passes down to a duct under the floor, then up to another duct where it is heated by coming in contact with hot steam pipes, and finally enters the car in the aisle through pipes under the seats. In the car the air rises and passes out through ventilators placed above the lamps. This system is also designed to change the air in the car about every four minutes.

These three methods of ventilation

* Railway Age. 1906, 42, p. 847.
† Proceedings, Master Car Builders' Association, 1908, 42, p. 338.

THE SOCIETY OF ARTS OF THE MASSACHUSETTS INSTITUTE OF TECHNOLOGY

The Society of Arts was established as a department of the Institute by President Rogers in 1861. It is especially devoted to the general dissemination of scientific knowledge, and it aims to awaken and maintain an interest in the recent advances and practical application of the sciences.

Any person interested in the aims of the Society is eligible to membership.

The annual dues are $3.

RICHARD C. MACLAURIN, President of the Institute.
ISAAC W. LITCHFIELD, Secretary of the Society of Arts.

EXECUTIVE COMMITTEE

ELIHU THOMSON
JAMES P. MUNROE
THE PRESIDENT
THEODORE N. VAIL
CARROLL W. DOTEN
FREDERIC H. FAY
THE SECRETARY

BOARD OF PUBLICATION

D. F. COMSTOCK
SELSKAR M. GUNN
ELLWOOD B. SPEAR
LEWIS E. MOORE
I. W. LITCHFIELD, Editor

SCIENCE CONSPECTUS is published December, January, February, March and April.

have one difficulty in common, that is, while they work reasonably well when the train is going at full speed, they are less effective at slow speeds, and give almost no ventilation when the train is standing still. In other words the amount of fresh air drawn through the car is directly dependent on the speed of the car. To remedy this, it has been suggested that fans be installed for use during stops. This would particularly be of service to those who are obliged to spend several hours in a sleeper standing in a terminal.

A short time ago a large number of tests were made on the air of Pullman cars in order to determine the efficiency of the ventilating system.* Samples of air were taken from different parts of the car, both when the train was moving and when standing at stations, and also from occupied and unoccupied berths. These samples were analyzed for carbon dioxide, which was used as an index of the purity of the air. From the analysis and the number of people in the car, the amount of outdoor air which is entering per hour can be calculated, that is the amount necessary to maintain the carbon dioxide at the value found by the analysis by dilution of exhaled air with outdoor air. The results obtained in this work led the investigator to conclude that plenty of fresh air is supplied in cars in motion, and even when standing still the contamination was not sufficient to be dangerous to health.

Still there is no doubt that a sleeping car does get "close" and "stuffy," with a resulting discomfort to the occupants. What causes this if analyses show that the air is not bad? Obviously we must look into the same factors which are responsible for our comfort or discomfort outdoors or in our houses, that is, the temperature, the humidity and the motion of the air, and the problem of sleeping car ventilation becomes the problem of regulating these conditions.

The question of motion of the air has been practically solved by the various ventilating devices, and any additional regulation can readily be made by means of electric fans. It is not considered practical † to regulate the humidity in a car, although if this could be done it would be one of the greatest factors in increasing the comforts of travel. The problem at the present time seems to be that of obtaining some efficient method of regulating the temperature of the sleeper and there is good reason to believe that this will be solved in the near future.

* Crowder. Archives of Internal Medicine. 1911. 7. p. 85.
† *loc. cit.*, p. 132.

SCIENCE FIGHTING AGAINST DISEASE

HEAD OF THE PASTEUR INSTITUTE OUTLINES THE PROGRESS OF MEDICINE AND INDICATES WHAT IS STILL TO BE ACCOMPLISHED

In a recent article written for the New York *Sun*, Professor Elie Metchnikoff, head of the Pasteur Institute, shows the progress of science against disease and points out what is still to be accomplished. This is an interesting record and we give it in full:—

Last summer I took two of my non-Russian colleagues, who were for the first time in Russia, to the Peschersky monastery in Kief. The monastery produced upon them a very deep impression. They were struck most of all by the appearance of the throng of pilgrims who were waiting in the courtyards and in the garden. The concentrated expression of their faces, which bore for the most part the imprint of profound grief, aroused a special sense of pity.

"We are partly responsible for this collected mass of misery," I said to my companions.

No doubt many of those who were there had come for the purpose of saving themselves from disease or for the purpose of praying that their nearest kin be healed of their ailments. It would be hard to imagine more effective evidence of the helplessness of our medical science. Indeed, what a great number of diseases there still remain against which medical art is powerless! With regard to such dreadful misfortunes as certain forms of insanity, numerous nervous diseases and malignant tumors science is groping in the dark. Powerless also is medical science against numerous children's diseases, against ailments of the heart, of the blood vessels and the kidneys.

It is remarkable that even in the case of numerous diseases whose causes have been definitely established there are no satisfactory remedies. The bacteria which cause all forms of tuberculosis, the pneumococci of pneumonia, the staphylococci and the streptococci which are the causes of various forms of suppurations, have been investigated in all their details and yet no positive remedy has as yet been discovered with which to combat them.

Nevertheless, hard work is being done in all institutions devoted to medicine in order to discover remedies. Aside from the hospitals and medical faculties this work is energetically carried on in special institutes whose aim it is to combat diseases. Every year their number is increased, and not only in Europe, but even in Japan, in Africa and in North and South America such medical institutes are doing successful work, as, for instance, at the Rockefeller Institute in New York and at the pathological institute at Rio de Janeiro.

Special attention is paid at these institutions to tropical diseases, the first place among which is held by the blood disease which was brought over to Europe more than 400 years ago, and which is raging everywhere. During the last year the greatest attention was directed with regard to this disease to the effect of salvarsan (606) introduced by Ehrlich.

The practical application of salvarsan called forth a large number of articles, chiefly of a polemic nature. Criticisms were directed with particular zeal against it chiefly by certain French physicians, who took a too narrow nationalistic view of the matter. Since salvarsan was discovered by a German, it could have no healing effect, especially since it became the subject of the most unbridled advertisements, they argued. All fatal cases that occurred after the application of salvarsan were immediately ascribed to its injurious action, notwithstanding the fact that salvarsan was often resorted to at the last moment, when the life of the patient was hanging on a mere thread.

But the cure of all possible forms of blood disease is a problem of such great importance that, notwithstanding the zeal of the opponents of salvarsan, Ehrlich's discovery has conquered for itself a solid place in medical practice.

It is true that the too great expectations of certain physicians and especially the public, who thought that a single injection of salvarsan was sufficient to produce a complete cure, were not realized.

Although the majority of deaths after the use of salvarsan cannot be ascribed to that remedy, there are certain cases in which it may cause death. According to Ehrlich there is no more danger to life in the use of salvarsan than there is in chloroform—even less. At any rate, salvarsan should be used very cautiously and should not be administered to patients with very weak, nervous systems and with certain derangements of the blood vessels and the heart.

A very interesting discovery which raises the hope that a vaccine virus may be discovered against the blood disease was made during the last year by the Japanese scientist, Noguchi, at the Rockefeller Institute in New York.

But salvarsan proved useful also in curing other diseases. In this respect the facts concerning the treatment of another disease of tropical origin, known as frambosia, are particularly interesting. Being very contagious, children are easily infected by it, and the disease is raging among entire communities in certain regions. It had spread and taken such deep root in Dutch Guiana that until recently there seemed no possibility of checking the disease. But since the discovery of salvarsan it has been used there extensively.

A special hospital was opened at Surinam, where patients suffering from frambosia were gathered, and to each one was administered a sufficient dose of this medicine. Two weeks later the last patient, and there had been 328, was discharged. As all the patients had been cured the hospital staff was dismissed and the hospital closed.

As I pointed out a year ago salvarsan cures not only chronic diseases, but also acute diseases, such as recurrent fever. As a rule, one injection is sufficient to produce a complete cure. This fact has been established in Russia, Spain and the Congo Free State.

Nevertheless it is necessary also in the case of recurrent fever to take preventive measures. As it is being ever more firmly established that this disease is spread by certain insects special attention is called to these insects. This same plan is effective even against a more dangerous disease than recurrent fever, namely typhus. After it had been definitely established that the latter is transmitted by the bite of an insect a campaign was started against these insects in southern Tunis, where typhus was raging. Simple measures of enforcing cleanliness and of burning material which harbored the disease-carrying insects were employed, under the direction of Doctor Hober, and proved sufficient to check the epidemic. It is surprising that in Russia, where recurrent and typhus fevers are so widespread, no efforts have as yet been made to guard against these diseases by restoring to hygienic measures.

Typhoid fever, which is of far greater importance than spotted or recurrent fever, was the subject of new investigations during the last year. Availing ourselves of the fact that this disease can be inoculated in anthropomorphous apes, Bezredko and I have tried on them the preventive vaccine against this disease. But to our surprise we found that its effect is very limited, so that this should not be taken seriously.

As a result of this other efforts were made to discover new methods of preventive vaccines. Bezredko has applied to typhoid fever the preventive method which has been discovered by him. The experiments upon a chimpanzee led to favorable results, and then the question arose as to the possibility of applying that method to human beings.

Meanwhile the former methods are used, consisting of hypodermic injections of typhoid bacteria killed by heat. In this respect we may note the inoculations made last summer by Vensan and Chantmesse upon the French troops that were

sent to Morocco and that were particularly exposed to typhoid fever. Judging by the accounts, the results were favorable, but unfortunately the information supplied in these reports is too meagre for a final judgment.

It is possible that these injections against typhoid fever will prove useful in extreme conditions, such, for instance, as in time of war or before the departure of an expedition for places that are strongly infected with the disease. But it cannot be said that they will be used extensively under ordinary circumstances. As typhoid fever infection, like that of cholera, is transmitted by drink and food, it is easy to guard against it by heating food or drink to the boiling point before using it.

The safeguarding against diseases transmitted by drink and food, such as diseases of the digestive organs, and against disease contracted through injuries to the skin of the body, such as intermittent fever and yellow fever, does not present any special difficulties. Therefore, very good results have been secured with regard to these diseases.

It is infinitely more difficult to combat infectious diseases that are transmitted by the respiratory organs and by the inhaled air. In this respect the first place is held by tuberculosis, against which no protection positive was discovered during the past twelvemonth, notwithstanding the enormous efforts that have been made in that direction. All possible serums and preventive vaccines tried on animals and in certain cases on human beings have yielded no favorable results.

Meanwhile it is necessary to conduct the struggle against tuberculosis on general hygienic measures, and although even in that respect nothing absolutely certain has been attained, still, thanks to these measures, this dreadful scourge of the human race is growing perceptibly weaker in most of the civilized countries. But this, of course, does not satisfy us, which explains our quest for new ways of solving the question of how to eradicate tuberculosis.

The tubercle bacilli of Koch have been investigated already as far as the means of modern science have permitted. With its aid the most varied preparations have been secured, by means of which efforts have been made to immunize animals against tuberculosis. In this respect something positive was even accomplished so that for some time it was thought that Behring's method might be applied with success at least in safeguarding horned cattle from this disease. But upon close investigation this also proved impracticable.

Meanwhile no artificial preventive vaccine has been discovered. And yet it is becoming ever more and more evident that the majority of people are safeguarding themselves from tuberculosis by some unknown, natural means. It has long been noticed that when the lower human races come in contact with the cultivated races the former soon develop tuberculosis in a strong degree, while the latter suffer from it only in the usual way. Does this difference depend upon the degree of racial susceptibility to tubercular infection or to some natural preventive of the cultivated races?

For the purpose of ascertaining this question, which is so important in combatting tuberculosis, we, my comrades Burne, Tarasevich and I, undertook an excursion to the Kalmuck steppes. We had to settle the question whether tuberculous infection was equally prevalent among the Kalmucks living in the steppes and those who were in nearer contact with the Russian population.

It turned out that there was a very significant difference to be noted: In the steppe, especially in its central part, there was less tuberculous infection than at its periphery. Coming in contact with the settled population the Kalmucks are infected by Koch's bacilli and they succumb to it more easily than the Russians. That was especially to be noticed with Kalmucks who came to Astrakhan for the purpose of entering the schools there. Coming there free from tuberculous infection they soon contract it, falling too often victims of the dreadful disease.

All these facts confirm the supposition as to the existence in nature of some means

of prevention which is independent of science and the human will.

All these theories are thus far only hypothetical; nevertheless they can serve as a basis for new investigations which have been undertaken as a result of our trip to the Kalmuck steppes.

The scientists are just as energetically seeking for means of combatting the other of the most dreadful scourges of the human race—malignant tumors. The amount of work undertaken for this purpose in European and American laboratories is astonishing, but until recently the results of these investigations have proved of a very slight consolation. Only toward the very end of 1911 the work of Wasserman and his co-workers appeared, raising considerable hope. The investigation of these scientists has opened a new way for treating the problem of malignant tumors which, it is to be hoped, will not be slow in yielding results for the good of suffering mankind.

In general the last twelve months have not passed without leaving some record of achievements in the struggle against our microscopically small, but none the less very powerful, enemies. Perhaps the time is not far off when scientific medicine will make superfluous such pilgrimages as that which astounded my foreign comrades who visited Kiev with me.

NEW MEMBERS OF THE SOCIETY

At the 677th meeting of the Society of Arts held February 6 the following applicants for membership were presented and elected:

Hon James Phinney Baxter, Portland, Me.
Daniel J. Danker, 73 Dean Road, Brookline, Mass.
Henry S. Dennison, South Framingham, Mass.
William B. H. Dowse, 95 Milk St., Boston, Mass.
A. M. Guinzburg, Medway, Mass.
Harry M. Hardwick, 40 King St., Roxbury, Mass.
George W. Holden, 895 Boylston St., Boston, Mass.
Frank F. Jonsberg, 733 Old South Building, Boston, Mass.
Herbert J. Keith, 72 South Market St., Boston, Mass.
George A. Kimball, 101 Milk St., Boston, Mass.
W. F. Kimball, 7 Beals St., Brookline, Mass.
John E. Rees, Tendoy, Idaho

PROLONGING LIFE BY THORIUM

The interesting discovery has recently been made by Dr. Werner von Bolton that the metal thorium has the property of destroying vegetable and bacterial growths, while certain forms of animal life seem to have a prolonged existence under its influence. Thorium causes fungi and even ordinary grass to die prematurely. Grass sprouts at first after treatment with thorium but dies in a short time if it is in contact with earth that has been treated with the metal. On the other hand, the lifetime of some fishes, *amphioxus lanceolatus*, is prolonged very greatly if thorium is added to their native environment, sea water and sand.

The experiments were carried out with the fish by dividing them into three lots. Two of these lots were placed in water that had been treated with thorium while the third was left in untreated water. After seven months over 90 per cent. of the fish in the thorium-treated environment were still living, while those in the untreated water died within five weeks. The walls of the vessel containing no thorium were covered with fungus, while the other two vessels were almost free from this growth. The fungus probably kills the fish and they were therefore able to live longer in the vessels where the inimical organisms had been destroyed.

It is not known whether the beneficial effects of thorium on animal life are due to the metal itself or to some other substance that is present in very small quantities. Some of the compounds of thorium have the same property but to a very much smaller degree. Other metals have been tried but none has been found to possess this singular influence.

Experiments are being carried out on other animals and it is hoped that thorium may be found to destroy some of the disease germs that shorten the life of mankind, without seriously affecting the functions of the human organism.

E. B. S.

ARCHITECTURAL ACOUSTICS

A SERIES OF INVESTIGATIONS TO DETERMINE HOW TO SECURE DESIRED ACOUSTICAL RESULTS IN PUBLIC HALLS AND ROOMS

Professor Wallace C. Sabine, of Harvard University, in a series of six lectures before the Lowell Institute, outlined the condition of "Architectural Acoustics," illustrating the papers by means of many experimental demonstrations and lantern projections. He noted in his initial lecture that the science has fallen into disrepute for it is popularly said to be impossible to determine in advance what the acoustical properties of a hall will be. This by the lectures was shown to be a fallacy and much of the time was devoted to the presentation of the results of experiments.

The investigation was due in some measure to the fact that the lecture hall of the Fogg Museum at Cambridge was found to be very bad acoustically. It was modelled after the Sanders Theatre, which is very good. The general condition which is most disturbing in audience halls is reverberation. In its highest theoretical possibility, with a room of which the walls are absolutely non-absorbent, a sound once made in the room will go on forever caroming from wall to wall. This extreme is never met of course, but in many halls the original sound continues until other sounds that are emitted, cover it and then there is confusion. An important factor, therefore, to the acoustic perfection of a hall is the absorbing quality of walls and furnishings. In the work, finding that Fogg Hall was too highly reverberative, Professor Sabine carried into it cushions from the Sanders Theatre. Every once in a while the acoustics of the Fogg room were tested and presently the investigator had a scale of reverberation expressed in metres of Sanders Theatre cushions. The scale was inconvenient, so as a substitute, open window space, was taken, which may now be used for the measure of the absorption of any room anywhere. Two other items enter into the question of rooms for speaking or for music, interference of sound and resonance. Interference is where the meeting of two sets of sound waves produces silence, which explains why in some auditoriums there are "deaf spots," while resonance is a condition in which the reflected sounds return just in time to reinforce the original sounds and make them unduly powerful.

The lectures were full of descriptions of poorly constructed places and the reasons why they fail. One house in New York was built intentionally to keep sound out, but the use of a pressed brick with a high grade cement makes a wall that is practically homogeneous where the transmission of sound waves are concerned. Then a brace or two from the brick wall to the lining of the sound-proof room made a resonator of it and noises of two stories below in the servants' quarters come forth magnified in the sleeper's chamber. In some music rooms of a college, supposed to be sufficiently guarded by the interposition of sound-proof partitions, the sound went from one to another. It was found that the pianos set the floor in vibration and the sound manifested itself in the vertical walls that rose from the floor.

One of the most interesting items shown was the method of testing the acoustic conditions in all parts of a room. A revolving arm was fixed to a vertical shaft which could be raised and lowered and a telephone was arranged on it to slide its length. It was possible by this device to place the telephone in almost any portion of the room. It was so connected that a continuous record of the intensity of a sound was made during

movements of the arm bearing the telephone. A constant sound of uniform intensity was produced and by means of the telephone it was possible to make a chart of the room in its acoustical qualities. This work is, of course, technical, but it serves to show how deeply the subject has been investigated by Professor Sabine and his assistants.

Some of the matters that were made clear were that the usual method of stringing wires across an auditorium to improve its acoustic qualities is useless because infinitesimal, to say nothing of the architectural effect. It was possible to establish a scale of absorptiveness, so that different kinds of wall decorations, cloths, curtains, rugs, sheathing, plaster walls, the portraits of one's ancestors, chairs, settees and the usual furnishings, may be rated as aids to the improvement of a hall. The coat of paint that is applied, may, under some conditions change the acoustical quality of the room by substituting a non-absorbent surface for an absorbent one. The value per individual of an audience was also tested out, the lecturer having detained a company or two at the Jefferson Physical Laboratory till midnight practically, trying the effects of additions and subtractions to the number. These and other tests were recorded by means of instruments.

The speaker noted that the idea of reconstructing a Greek theatre, which normally is fitted for out-of-door companies in warm countries, within a building, presents no good reason for the securing of the same acoustic effects. There enter into such questions materials for construction which must be taken into the reckoning.

One point of interest in the investigation was the rating of the human ear and judgment by means of scientific records. Tests were made of a number of music rooms. A committee of musicians first pronounced an opinion on the different rooms, rating them as too resonant, or too dead. Experiments with the rooms showed that no room that was pronounced dead was more resonant than the least resonant of the good rooms, so the ear judgment was confirmed by science. A similar test was made by another group of musicians of the various halls and auditoriums in the country, just previous to the building of the new Symphony Hall in Boston, and in these, science and the musical ear again agreed.

One of the interesting incidents to the story was the outlining of system with which the building of this hall was undertaken and to which it owes its excellent acoustics. The outcome of the experiments has been to place architectural acoustics on a firm basis and to make evident the fact, that today it is possible to build with a knowledge that if the proper principles are followed the acoustical result will be entirely successful.

THE GENESIS OF PETROLEUM.

The United States Geological Survey has recently contributed some interesting information relative to the connection between local magnetic disturbances and the genesis of petroleum.

Mr. George F. Becker, the investigator, states that some oils are undoubtedly organic and some are inorganic. They may have been derived from carbonaceous matter of vegetable or animal origin and they may have been derived from carbides of iron or from metals. It is possible, too, that the hydrocarbons exist as such in the mass of the earth.

In studying the connection between the behavior of the compass needle and the distribution of hydrocarbons, Mr. Becker found that on the magnetic declination map of the United States, the irregularities of the curves of equal declination of the compass were strongly marked in the principal oil regions.

The observations are to some extent supported by conditions in the Caucasus where great magnetic disturbances exist. The theory of the inorganic origin of the hydrocarbons is not proved by this study, but the map referred to above shows that petroleum is intimately associated with disturbances similar to those affected by the proximity of substances possessing sensible magnetic properties such as iron, nickel, cobalt and magnetite.

SOLVING ELECTRIFICATION PROBLEMS

In the twenty-five years of experience with heavy electric traction two problems have been most acute, the economical transmission of power to the train and the design of motors to meet the very severe requirements of the service. Through evolution the direct-current motor has reached a remarkable state of efficiency and reliability as motive power. However, it has a serious handicap, in that the power must be delivered to it at relatively low pressure, ranging from 500 to 2000 volts. The most economical method of making this delivery is to generate alternating current, transmit it at high voltage to sub-stations, transform it to a low potential by transformers and convert it to direct current at trolley voltage by rotary converters. The system is costly, complex and relatively inefficient.

The single-phase, alternating-current system is a radical departure from the above and aims at economy in power transmission. Power is transmitted at the most economical pressure and stepped down at intervals through transformers to a trolley voltage which may be as high as 12,000. The economy of copper transmission wire so obtained is great and the converting apparatus is most simple and efficient. The locomotive or car carries a special step-down transformer and is equipped with low-voltage motors. The performance of these alternating-current motors, however, is distinctly inferior to that of their direct-current competitors. They are heavier, more bulky, and more expensive. They are less efficient, more liable to spark badly and have much less reserve power. Furthermore, there is little prospect that these faults will be greatly diminished.

It is apparent that the direct-current system sacrifices economy of power transmission to excellence of motive power and that the situation with the alternating-current system is precisely the reverse. This contrast is fully confirmed in practice. The direct-current system has been most successful with dense traffic within a limited radius; the single-phase system has shown to advantage only with long hauls and infrequent stops. The most recent developments aim to mediate between the two systems and conserve the advantages of each. Simple, reliable and economical means of converting alternating current to direct is needed to supply the essential link.

One method of doing this is by means of an instrument called a rectifier.

Of all such rectifiers the mercury arc, which is in its action similar to a valve permitting current to flow in but one direction, is the most promising. As ordinarily constructed the arc is formed in a glass vacuum tube. The device is reliable and efficient but rather fragile and adapted only to small currents. A new type has been brought out in which the arcs are formed in steel tubes artificially cooled by oil or water. The tubes are made in two sections with asbestos gaskets and mercury packing to maintain thorough insulation and high vacuum. Such tubes are equally well adapted to single-phase and three-phase working. They have been built for currents as high as 300 amperes per tube. Apparently higher currents can be handled quite as easily and the device is adapted to any direct-current voltage for which motors can be wound. The sets are extremely light and compact. They may easily be carried on locomotives or cars, but a step-down transformer is required if an economical trolley voltage is employed. As a substitute for rotary converters in sub-stations the tubes will show marked advantages in first cost and operating economy. A complete outfit for fifty kilowatts (about sixty-five horsepower) gives an efficiency of 90 per cent. and large sets should attain from 93 per cent. to 95 per cent. Engineers familiar with these developments confidently predict that they will bridge the gap between the two systems of electrification.

The Paris, Lyons and Mediterranean system has been experimenting on a large scale with an entirely different device with the same end in view. It has in service a locomotive of 135 tons which receives its power from an 11,000-volt trolley and converts it to direct current by a revolving commutator driven by a synchronous motor. A transformer is used in the alternating current side to give 300-volts for the direct-current motors. The locomotive has been severely tested on a section of road having grades of 2 per cent. and hauled a train of 260 tons at an average speed of forty-five miles per hour.

It is certain that the last word in electric traction has not yet been spoken. The railroads which have been pioneering with the existing systems have achieved creditable success, but there is still much to be desired. In view of the tremendous financial burdens involved in electrification the slow growth toward a standard system justifies the conservatism of the railroads in the face of the unquestioned economy gained wherever electrification has been tried. W. E. W.

CREATING ARTIFICIAL RESPIRATION

Two machines for producing artificial respiration have recently been made public.

A German invention called the "pulmoter" consists of a tank containing oxygen at a pressure of 2800 pounds per square inch, which not only furnishes the life-sustaining gas, but also the energy required to reproduce the action of natural breathing. The oxygen flows through a reducing valve, and from there to the controlling valve. Here it has free passage to the lungs. When the pressure reaches a certain value, a bellows connected with the apparatus creates suction, causing an exhalation of the oxygen previously forced into the lungs. When a certain vacuum has been reached, the outer atmosphere acts upon the bellows in such a way as to reverse the operation. The frequency of the respirations can be adjusted to the size of the lung cavity. One of these machines is now used by the Commonwealth Edison Company of Chicago for resuscitation in cases of electric shock.

Another machine for accomplishing the same results has been devised by two physicians of Chicago, and is intended to maintain artificial respiration during operations of lung surgery. In general principle it is somewhat similar to the pulmoter, the mechanism being so devised that it produces alternate pressure and vacuum, simulating natural respiration. Recently, this machine was used to sustain the life of a patient twenty-nine hours after the time at which all signs of animation had ceased, while the surgeons were attempting to provide relief through surgical means. This apparatus introduces atmospheric air into the lungs, instead of oxygen.

DUAL WATER SUPPLY

A NOVEL scheme of dual water supply is proposed by Professor William T. Sedgwick of the Massachusetts Institute of Technology. His plan is intended to prevent the economic waste due to providing bacterially pure water for all municipal and private purposes, by providing two supplies, one for drinking and culinary purposes, and a large denatured supply for all other purposes. The special supply, being small in quantity might be found nearer a city than a large supply of high-grade water, and in any event could be readily subjected to whatever degree of purification might be required. The large supply could be taken from any convenient near-by source which afforded water of quantity and character suited to industrial purposes.

Denaturizing with a relatively large application of hypochlorite of calcium, a harmless compound used widely in minute quantities to treat potable drinking water, would give the water such a taste and odor as to shut it out for drinking and cooking purposes, and at the same time kill all possible disease germs which the water might contain.

This plan is brought forward, to meet some of the especially difficult water problems of today.

A TRIBUTE TO LORD LISTER

In a recent address before the students of Sanitary Science and Public Health at the Massachusetts Institute of Technology, Professor William T. Sedgwick paid a feeling tribute to Lord Lister, the great English surgeon who passed away this month:

"Almost the last of that splendid group of scientists of the last century," said Professor Sedgwick,—"a group that included Darwin, Pasteur, Tyndall, Hooker, Helmholtz, Spencer and Koch,—Lord Lister has passed away; he who was the discoverer of modern surgery." Pasteur and Lister and Koch formed a great micro-biological force; in 1895 Pasteur died, about two years ago, Koch, and now Lister, the last of the great trio, has gone.

Professor Sedgwick outlined the notions of the ancients on the subject of disease. There was first the theory of demons and then of the four humors. The idea of spontaneous origin of disease afterward became the accepted one and was used indeed to account for the origin of animals, the bees giving to Virgil and other poets many occasions for exploiting the idea.

When Pasteur began his work he had to meet the objections of such men as the brewers, who thought that the troubles of wine and beer were of spontaneous origin. Pasteur showed that all microbic life comes from pre-existing life, but it took a Tyndall to clinch this belief.

There was not as yet any idea of the relations of dirt to disease, but what Pasteur showed was that the whole superficial earth is quivering with life. One man had approached this idea before Pasteur, Semmelweiss, a Hungarian physician educated and established in Vienna. Deaths in the maternity hospital there were numerous, and it was noticed that in the students' clinic they rose as high as 16 per cent. of the cases. Semmelweiss found that these students came directly to the hospital from the dissecting room, and the death of one of them from a cut made Semmelwiess order hand washings and other precautions, resulting in a fall to less than 2 per cent. This was done about 1850 and without the knowledge of today that dirt means death and destruction, but it was an important movement along the same sensible lines.

Professor Sedgwick laid emphasis on the fact that before Lister's day to go to a hospital was almost to go to a slaughter house. The chances of surviving an operation were small, and it is this feeling that persists among those who depend upon tradition that makes the less intelligent classes dread the hospital today.

It was this great loss of life that Lister conquered by his methods. In 1860 Pasteur was at work on fermentations, while young Lister was a surgeon interested in the microscope and in wounds. He became acquainted with the discoveries of Pasteur and certain other experiments, and applied them to wounds. There had been experiments in filtering air through cotton; Pasteur used gun cotton and dissolved it, finding then that it had caught spores and "animalculæ." Lister saw at once that if this were true, the key to the whole surgical situation would be, simply to keep these things out of the wounds.

Surgery was naturally out of fashion before 1846. It was both dangerous and painful and the most rapid work was best esteemed. In the demonstration of ether as an anæsthetic at the Massachusetts General Hospital, in 1846, however, it seemed as if surgery was to have a much more important place, but for a time anæsthesia actually made the situation worse. There was less pain and more surgery, but not more saving of life.

This was the situation when Lister caught the great idea. At about this same time carbolic acid was introduced, and Lister began then his antiseptic treatment, the killing of the germs. He made one error, for the belief was that

the germs were chiefly in the air. Lister sprayed the air, but did not at first know of the dangers from fingers and tools. His work was antiseptic, killing of germs in wounds, a work in the curative line. From it has grown the aseptic method, the keeping out of germs, or the line of prevention. The world has since seen the triumph of aseptic surgery, a sure foundation on which rests today the most brilliant section of therapy.

Some are inclined to decry Lister and rate him merely a follower of Pasteur. The true position is that taken by an eminent English authority, who finely said of him, "But though Lister saw the vast importance of the discoveries of Pasteur, he saw it because he was watching on the heights:—and he was watching there alone."

"Pasteur, next to Darwin," said Doctor Sedgwick, in conclusion, "was the greatest man of the nineteenth century, and after Pasteur should always be placed Robert Koch the German and Joseph Lister the Englishman, for these three were the founders of micro-biology, modern medicine and modern surgery."

STRUCTURAL STRENGTH OF PLANTS

The ability of certain plants to maintain an erect attitude in spite of excessive slenderness is truly remarkable. A stalk of rye, for example, may commonly attain a height of five or six feet, with a diameter at the base of only one tenth of an inch, a ratio of 500 to 1. Compared with such figures the slenderest man-made structures appear short in proportion to their height. The loftiest chimneys seldom reach a height of twenty times their diameter, and to meet the proportions of the rye straw and retain its present height, the Washington monument would have a diameter at the base of but thirteen inches. The disproportion is all the more startling when we consider that the rye stalk has further a very considerable weight of grain to support at its summit.

This remarkable stability of plants is due in part to a specialized system of extremely tough tissue comparable to the steel framework of a modern building. Careful measurements have shown this tissue to have a sustaining strength equal to that of the best wrought iron, while its ductility is ten or fifteen times as great. Not only is this material inherently strong, but its arrangement is such as to render it structurally most effective. The constructions are often extremely ingenious, and are a pretty example of the adaptation of the plant body to the requirements of its environment.

F. S., JR.

IMPROVING THE MERCURY VAPOR LAMP

The difficulty with the old form of carbon arc lamp has been the cost of the renewal of the carbons and the bother incidental thereto. Various forms of arcs which require no renewal have been proposed from time to time. Of these the best known is the mercury vapor arc. This, however, is not popular on account of the ghastly light which it gives. By raising the temperature of the arc, it is possible to get a luminous yellow light which is very pleasing. The glass tube which contains the mercury, however, melts at these high temperatures. Recently a quartz tube has been perfected which enables the necessary high temperature to be attained in order that the light may be yellow. This gives a very pleasing light. This arc lamp requires no attention except in case of actual breakage. It is stated that some fifty of these are in use in France and that one is in use in this country. L. E. M.

The Navy Department has a plan for a chain of wireless stations which will bring it into communication with battleships wherever they may be located. The chain includes a station at Arlington, Va., San Francisco, Cal., Pearl Harbor, Hawaii, the island of Guam, the island of Luzon in the northern Philippines, and Tutuila Island, one of the American Samoan group. Each of these stations will be equipped with a 100-kilowatt generating apparatus, and each will have a sending and receiving radius of 3,000 miles.

SCIENCE CONSPECTUS

VOL. II MARCH, 1912 NO. 4

A GIGANTIC ENGINEERING UNDERTAKING

HOW THE PROBLEM OF SUPPLYING NEW YORK WITH WATER HAS BEEN SOLVED—UNPRECEDENTED SIZE AND CONDITIONS MAKE IT A PIONEER ENDEAVOR

BY FRED F. MOORE

THE water now supplied to our greatest city comes from both surface and underground sources, mostly owned by the municipality. These sources, together with the ultimate capacities, are as follows:

Source.	*Ultimate Capacity Million Gallons Daily.*
Croton system supplying Manhattan and most of the Bronx	335
Bronx and Byram system supplying part of the Bronx	20
Ridgewood system supplying most of Brooklyn and Municipal supply in Queens	155
Private water companies supplying parts of Brooklyn and Queens	30
Staten Island system supplying Richmond boroughs	10
Total	550

The Croton system is a surface supply developed by some ten artificial storage reservoirs and many natural lakes and ponds, over some of which the city has control. These reservoirs and ponds, controlled by the city, have a combined available storage capacity of about 100,000 million gallons on a watershed of 360 square miles. The latest of these reservoirs to be constructed has been empty since its completion two years ago, the dry weather not having furnished enough stream flow to fill it.

Water from the Croton watershed is brought into the city through the old Croton aqueduct of 90 million gallons daily capacity, finished about 1842, and the new Croton aqueduct of 290 million gallons capacity completed in 1890.

The Bronx and Byram system is a surface supply obtained in 1884, the water being delivered to the city through a 48-inch cast-iron pipe. Lake Kensico, the lowest storage reservoir of this system, is now being superseded by the new Kensico reservoir of the Catskill system which will flood the margin of the old lake to a depth of over 100 feet.

The Ridgewood system is a combined surface and underground supply which has been gradually extended eastward on Long Island to the Suffolk County line, where further development has been stopped for the present by legal proceedings. Water is conveyed to the city through the Ridgewood masonry aqueduct of about 66 million gallons daily capacity, and through several pipe lines.

The water supplied by private companies in Brooklyn and Queens is ob-

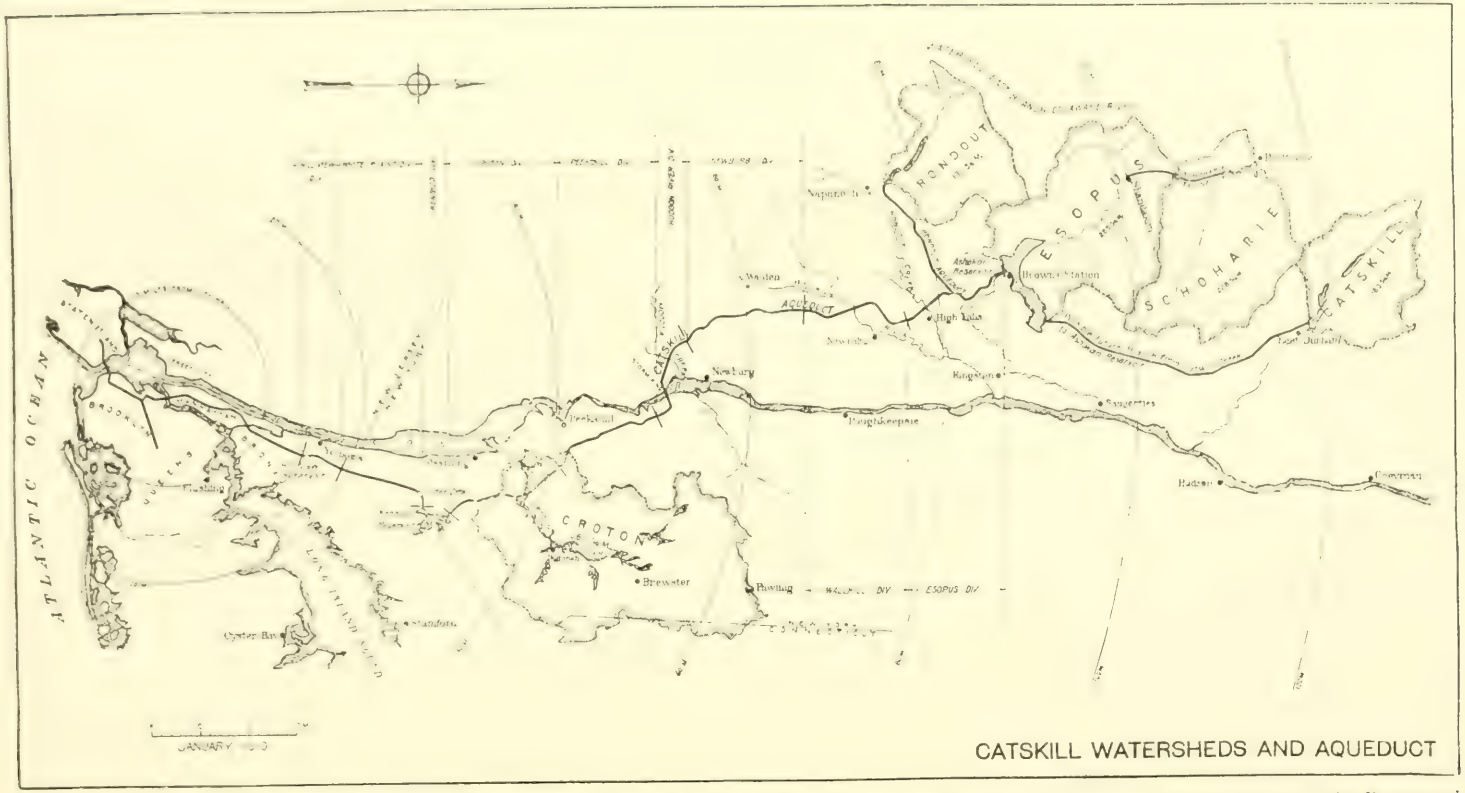


Fig. 1. Catskill Water System. Watersheds and aqueduct. Shows also the Croton watershed, the principal source of present supply; the Bronx and Byram watersheds are immediately adjacent to the Croton on the south

tained entirely from wells. These privately owned water systems are small; the largest, supplying part of the Flatbush section of Brooklyn, furnishing about 12 million gallons daily. The Staten Island system is a driven well supply unsatisfactory both in quantity and quality.

Rainfall is the source of all water supply, and other things being equal the smaller the rainfall for a given period, the lower will be the water supply. As a rough approximation about one half of the total rainfall in the vicinity of New York is evaporated either directly into the air or through vegetation: the other half goes into stream flow either directly by run-off from the surface or indirectly by underground movement.

To fully develop a surface supply, it is necessary to have storage capacity sufficient to hold the flood flows, to tide over the period when the natural stream flow is low, in order that water accumulated irregularly from precipitation may be used at a comparatively uniform rate. For the ground water supply, this equalizing storage capacity is provided in the pores of the subsoil. It is evident that in neither case can more water be drawn off than reaches the place of storage. Experience has shown, for example, that with the driven well system on Long Island the attempt to pump too much water results in the gradual lowering of the ground water level, and the drawing in of salt water from the ocean by reversal of the normal ground water slope.

All of the present supplies for New York City are developed fully up to their reasonable capacity. Irresponsible statements have frequently been made that it is a waste of money to construct the Catskill system, because the water that was wasted over the spillway of the new Croton dam during the exceptional flood flows in the winter of 1907–08, might have been saved by the building of more reservoirs in the Croton watershed. Records of stream flow of Croton River since 1868 show that it would be necessary to provide a reservoir capacity nearly four times as great as that now existing on the Croton watershed at a cost of something like $150,000,000, in order to prevent any water from wasting over the spillway of the new Croton reservoir during the forty-year period from 1868 to 1907, while the supply added by this means would be less than 50 million gallons daily. To compare with this, the Catskill supply will furnish more than ten times this quantity of water at an estimated cost of $162,000,000. The eighteen years from 1869 to 1886 gave an average daily flow of Croton River of 346 million gallons per day, while the following eighteen years from 1887 to 1904 showed a corresponding flow of 449 million gallons per day, nearly one third more. These later years of high stream flow, so long continued, tended to make one forget the probability of a recurrence of the conditions of low flow which are apparently now upon us. During the summer of 1911, the Croton reservoirs were very low, and would have been lower but for the success of decisive measures taken to reduce the consumption of water. If the conditions of the dry eighteen-year period were to be exactly repeated now, an estimate shows with reasonable allowance made for a normal increase in total consumption of water due to growth of population, there would never be any more water wasted over the new Croton dam, until the situation was relieved by the bringing in of another supply.

Within less than ten years after the completion of the new Croton aqueduct, it became evident to competent students of the situation that the increasing use of water due to the rapid growth of the city was making existing sources of supply really an unsafe reliance in spite of the apparent adequacy resulting from the then abnormally high rainfall. As far back as 1896, the problem was considered by the Manufacturers Association of Brooklyn. In 1899, Comptroller Coler brought about an investigation of the available sources by Consulting Engineer John R. Freeman, M. I. T., '76. In 1901, following this agitation, a bill was introduced in the legislature, looking to the creation of a commission empowered to add to the water supply of the city. Still later, in 1902, Commissioner of

Water Supply Robert G. Monroe appointed the Burr-Hering-Freeman Commission to investigate the question.

As a result of all these studies, the legislature on June 3, 1905, under chapter 724 of the laws of that year, authorized the work now being carried out by the Board of Water Supply. Mayor McClellan on June 9, 1905, appointed the first members of the board from three lists of three names each submitted by the Chamber of Commerce of New York, the Manufacturers Association, and the Board of Fire Underwriters. These commissioners, J. Edward Simmons, Charles N. Chadwick and Charles A. Shaw were confronted with the task of determining sources of supply from which water was to be taken, the location and equipment of offices, and a thousand and one details involved in establishing a great enterprise for delivering and distributing to the metropolis five or six hundred million gallons of water daily.

As eventually perfected the organization is divided into three bureaus,—administration, engineering and police. Of the administration bureau, the secretary, auditor, chief clerk, adjuster of taxes and assessments and examiner of real estate and damages, with their staffs aggregating 100 perform the duties designated by their titles. A police bureau under an inspector comprises 80 sergeants and 270 patrolmen for policing the territory in which construction is carried on, enforcing sanitary measures imposed by the board through its contractors upon their employees and through its mere existence furnishing moral protection to local communities.

The engineering bureau comprises on the staff of the chief engineer, J. Waldo Smith, M. I. T., '87, appointed August 1, 1905, a deputy chief engineer, a department engineer as personal assistant, and four consulting engineers. The general force is under five other department engineers.

Headquarters department has in charge the preparation of designs and specifications, the inspection of construction materials before delivery, technical experiments, and investigations and general administrative matters involving personnel, supplies and equipment. Reservoir department is charged with all surveys and construction in the watersheds. To Northern Aqueduct department was assigned field investigations, surveys and construction of a sixty-mile stretch of aqueduct from the Ashokan reservoir across the Hudson River to the Croton watershed. At this point the territory and work apportioned to Southern Aqueduct department begins and comprises the Kensico and Hill View reservoirs, thirty miles of aqueduct and the proposed Eastview filters. City Aqueduct department is supervising construction within the city limits.

Experts in specialized lines, such as geology, filtration, landscape work and sanitation of camps are engaged as needed.

In headquarters department there is an executive division upon contracts, statistics, reports and general executive duties, a designing division, preparing plans, specifications and working drawings, an inspection division with headquarters at the testing laboratory and assistants in various factories and cement mills, and a real estate division to prepare estimates and agreements with property owners and maps, and descriptions of lands required.

The four field departments are each also divided into an executive and a number of other divisions, and these in turn into sections, each responsible for an aqueduct length of three or four miles representing $1,500,000 or $2,000,000 of construction; some sections supervise reservoir contracts of still larger amounts.

At the height of activity of this great work, there are more than one thousand employees in the engineer bureau, including engineers and engineering assistants of all grades, clerks, stenographers, laborers and gage keepers.

Immediately upon his appointment, the chief engineer assembled a small force, and began study of the engineering problems, while working out the organization and equipment for the work ahead. This study was prosecuted to such good purpose that on October 9, 1905, the Board of Water Supply submitted for

Fig. 2. Catskill Aqueduct. Typical cut-and-cover construction in open cut: completed invert in foreground, followed by interior and exterior forms; completed arch and refilled trench. Locomotive crane depositing concrete brought by dinky train from concrete plant in distance

approval to the Board of Estimate and Apportionment, a plan for obtaining from the Esopus, Rondout, Schoharie and Catskill creeks a supply of not less than 500 million gallons daily at an estimated cost of $161,857,000.

The preliminary surveys and investigations proceeded rapidly from this time on. As the Hudson River crossing was a primary controlling point in the aqueduct alignment, borings were early started at several places in the Hudson River. More than 200 borings were made on fourteen cross-sections between Pegg's Point and Storm King, a distance of about fourteen miles. The early work, including study of aqueduct alignment on both sides of the river, resulted in soon fixing attention quite definitely on the Storm King-Breakneck crossing, and efforts were directed toward developing the shape of the gorge and the character of the rock at this place. It early became evident that rock was at such depths in the gorge, certainly more than 600 feet below the river surface, that adequate investigation by borings from the river surface alone would consume too much time. The material over the rock is penetrated by the wash rig. This is a device of two iron pipes, one within the other, with the necessary machinery for churning the inner one, while a stream of water under sufficient pressure is forced through it to the bottom, and up again in the annular space between them to the top, carrying up by the force of the current the displaced sand and clay. As progress is made in churning down the inner pipe, the outer one, or casing, is driven down from time to time. With this outfit was used at times, a heavy chisel-shaped plunger within the casing, which, actuated by machinery, chopped up or displaced the larger obstructions in the way of the casing. The diamond drill used to penetrate rocks, including boulders encountered in the wash rig borings, consists of a steel bit around the edge of which is set black diamonds. By rotating this bit, a circular cut is made in the rock, and a cylindrical core somewhat smaller than the inner diameter of the bit, detached. By the use of suitable tools, this core when from good strong rocks may be brought to the surface in considerable lengths for examination and study. By proper attachment to jointed

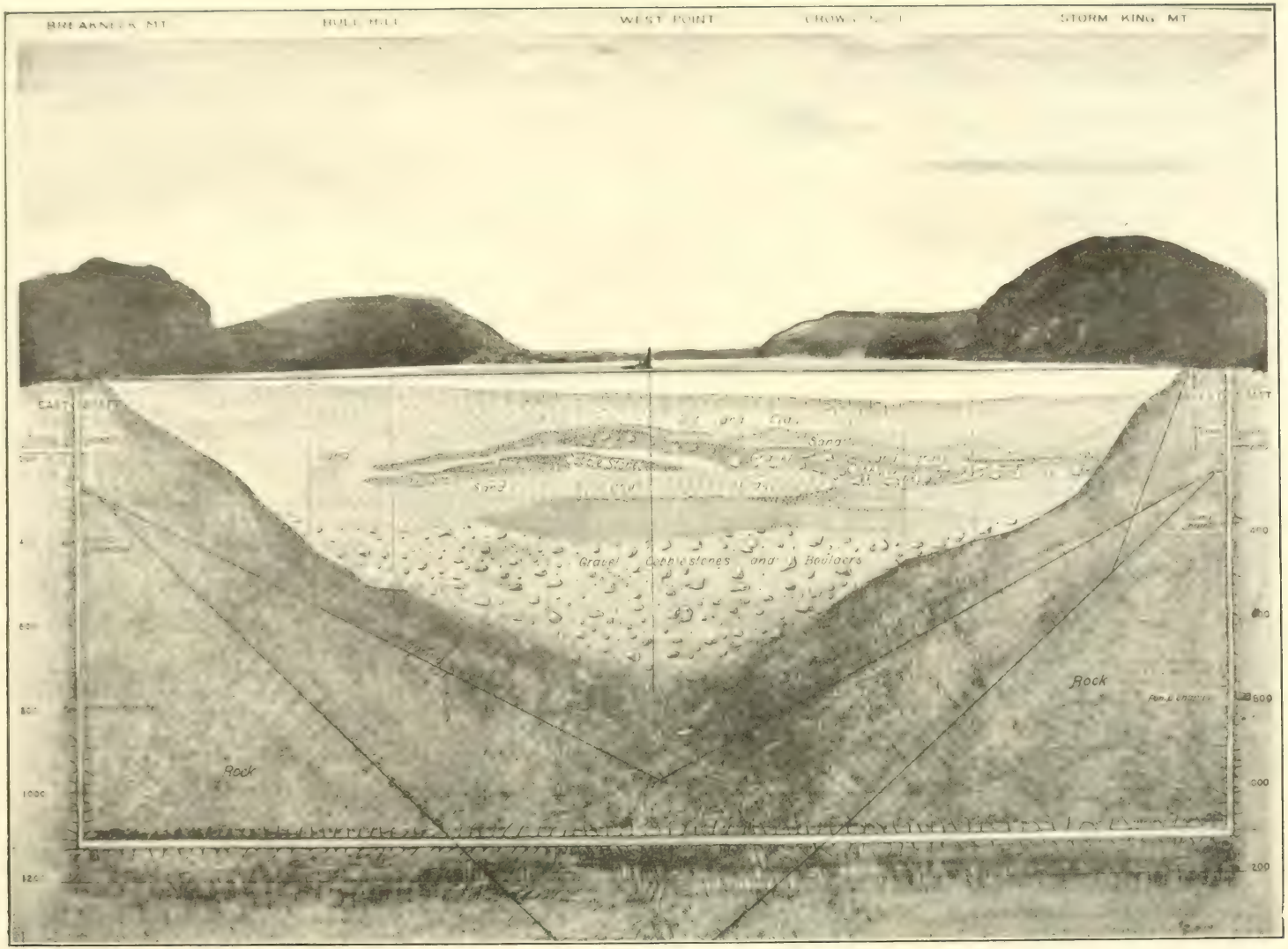


Fig. 3. Catskill Aqueduct. Hudson River siphon. Test shaft on each side of the river which will be a part of the permanent waterway. Inclined and vertical borings with drill rig on the river. Excavation of tunnel completed January 30, 1912

tubes, the diamond drill may be used for boring also inclined holes in rock. The complex character of drift filling in this river gorge, with numerous intermixed boulders, made it necessary to reduce the size and recase the holes frequently. Some of the later borings were started with eighteen-inch casings, in order to make possible the necessary reduction in size, as the depth increased. The work also suffered largely from the menace of river traffic. Several times after holes had been slowly and with great effort pushed deep into the drift an unmanageable or carelessly handled steamer or scow collided with the drilling outfit, and the hole was lost. Accordingly, it was decided to sink a shaft on each side of the river, designed to become eventually a part of the aqueduct, unless the rock conditions were found unsuitable for a deep pressure tunnel. Agreement for this was executed in February, 1907, and during the calendar year shafts were excavated to a depth of about 250 feet, when the work was abandoned by the contractor. After the unfortunate delay occasioned by this complication, shaft sinking was resumed by the Board with its own forces. As soon as the shafts had reached sufficient depth, about 300 feet, inclined diamond drill holes were started towards the river from drill chambers excavated in the sides of the shafts. The first pair of these holes was inclined at an angle about forty-five degrees to the horizontal. These borings were continued until they crossed near the middle of the river almost 1500 feet below its surface, requiring a length of nearly 2,000 feet for each hole. A second pair of holes was drilled from the same chambers, but at an angle of twenty-three degrees with the horizontal. These holes about 1650 feet long terminated near the middle of the river about 960 feet below the water surface. These holes were all in granitic gneiss, and comparatively little water was encountered. While this boring was going on, consistent progress was made in shaft sinking. An interesting phenomenon developed when the shafts had reached a depth of about 800 feet. The rock, although sound and hard, would spall from the sides with a loud noise and sometimes in considerable masses. This "popping" of the rock became more frequent and dangerous as the depth increased, and it was finally necessary to substitute steel lining for the timbering ordinarily used in such work. The "popping" appears to result from the removal of support, through the excavations, from rock masses which at these depths were highly stressed.

The completion of the diamond drill borings, defining as they did a zone within which the character and condition of the rock was felt to be pretty definitely known, permitted fixing the elevation of the tunnel at about 1,100 feet below the river surface. The shafts were sunk by the board's forces to the elevation of the tunnel headings and several hundred feet of tunnel excavated from each shaft, when a contract for the remaining work was let in June, 1911. The work was prosecuted by the contractor to such good purpose, working from both shafts, that a small quantity of rock intervening between the two headings was shot away when Mayor Gaynor pressed a button at the simple, but impressive, ceremonies at the opening of the tunnel January 30, 1912. Thus was brought to a successful conclusion that part which has been more discussed than any other, especially in the way of adverse criticisms by ill-advised critics.

The determination of the final location of the aqueduct, involving investigation of sub-surface conditions under several other deep valleys, in general required a careful investigation of many alternative lines, and their study with reference to the cost of the structure, and its ultimate security and other factors of topography, geology, accessibility and the availability of construction materials, especially of concrete aggregates. There are four principal types of aqueduct structure, standing as follows in order of cost per linear foot, beginning with the cheapest construction; cut-and-cover, grade tunnel, pressure tunnel and steel pipe siphon. As finally located as much as reasonably possible of the line is of cut-and-cover concrete aqueduct on account of its rela-

tive cheapness. In the same way whenever the geological conditions are suitable, valleys are crossed by pressure tunnels deep in the rock; this type being cheaper than steel pipe laid at or near the surface.

The total fall available for producing flow in the aqueduct is distributed among the different types of construction in inverse ratio to their cost per linear foot. Thus the greatest fall or slope per unit of length is given the most expensive type, the steel pipe siphons, that the size, and hence the cost may be properly balanced. In the same way each type has been given a slope consistent with its cost, the smallest slope being that of the cut-and-cover construction as it is the cheapest. The gradient is further adjusted by increasing the slope at the upper end to compensate for a decreased carrying capacity which would otherwise obtain through greater fouling of such aqueducts near the headworks.

The design of these works on account of their unprecedented size was in many of its phases pioneer endeavor. The effect of temperature changes upon masonry had to be very carefully considered in these water works structures where leakage is of such importance. A careful consideration of the corrosion of metals led to the considerable use of bronze and other non-corroding alloys for these works which must be designed to give long and continuous service.

For controlling, screening and measuring this river of water some sixty gate, screen and gaging chambers are required. Eight of these structures, for primary control, and for screening, are of great size; the superstructure of the largest gate chamber, one of those at the Ashokan reservoir, is about 50 feet by 140 feet. In these structures are many large sluice gates and gate valves which are among the most interesting of the mechanical engineering problems. Some of the gates operate under more than 100 feet head. The largest of the sluice gates are 6 feet by 15 feet, and weigh more than eighteen tons. Aërators are to be constructed at the outlets of both the Ashokan and Kensico reservoirs for treatment of the water when desirable. These aërators will be very interesting fountains of unusual size, each having almost 2,000 nozzles of discharge area three times that of the fire nozzles ordinarily used. In connection with the construction of the Ashokan reservoir, about thirteen miles of railroad is to be relocated, and in the watersheds and along the aqueduct many miles of new highway must be constructed.

Expedition work for any one of the contracts into which the undertaking is divided is alone, as distinguished from the permanent construction, an activity of magnitude. Before any considerable progress on permanent construction can be made, railroads must be built, power plants erected, power, light and telephone wires installed, and pipes laid for water supply and sewerage and in some cases, pipes for compressed air transmission. For some of the work, notably the longer tunnels, the central power plants become very pretentious undertakings.

The contracts of the board are painstakingly drawn to prevent danger to health of communities and individuals, including the men engaged in construction, which might result from the presence of many workmen, mostly illiterate, and unused to even ordinarily good standards of living and cleanliness. All along the line, the contractors are bound to protect public and private water supplies. Good buildings for housing the workmen, suitable stables for animals and ample and well-equipped hospitals, all located under expert supervision, are required. Supplies of water ample in quantity, and of suitable quality for all purposes must be provided. Collection and disposition by incineration, or other suitable means, of human wastes and garbage is insisted upon.

Within the limits of the Croton and other important water-sheds, through which the southern portions of the aqueduct passes, the sanitary regulations and measures are even more rigid. Each of these camps is a community in itself, sometimes isolated by a man-proof fence, and is, in addition to the above-mentioned features, which are general,

Fig. 4. Catskill Aqueduct. Rondout pressure tunnel, 14 feet, 6 inches diameter. Excavation in Hudson River shale and finished length of concrete lining; grout holes visible in arch keys. Other pressure tunnels, including Hudson River crossing, differ somewhat in size; but are similar in shape and structural details

provided with special disposal works for treating camp sewerage and drainage. These disposal works, in general, consist of a filter plant into the effluent of which a suitable quantity of hypochlorite of lime solution is added to effect a high degree of disinfection before the water passes into the nearest water course or lake. These filter plants in some cases treat also tunnel drainage and run-off from spoil banks. In some cases, it is deemed better to treat the whole flow of the stream with hypochlorite of lime by means of a dosing plant, consisting essentially of a solution tank and apparatus designed to automatically proportion the dose to the quantity flowing in the stream. The effective control of sanitary conditions is imperative on account of the magnitude of the work, and the vast number of people who otherwise would be exposed to real danger, imposing upon the city moral and legal obligations which have been met in an unprecedented and thorough manner in the work of the Board.

A brief description of one of the largest camps will illustrate the working out of this part of the problem. The construction of the Ashokan dams requires an army of about 3,000 men who live, many with their families, in a camp built by the contractor near the work. Italians and negroes live in separate sections. There have been provided sewerage and water supply systems, a special plant for the disposal of sewage, good dwellings, generally one-story wooden structures, with screens on doors and windows, well-lighted streets, electric lights, telephones, a savings bank, hospital, general store, bakery, police organization, fire protection, and a kindergarten and schools for children. An evening school for men is one of the features of the camp. An eight-hour day gives plenty of time to attend the school where the English language and the elements of national, state and city governments are taught. These camp-schools were instituted by the commissioners personally, and have been supported by private subscriptions with the assistance of the contractors. Besides the main camp-city, there are

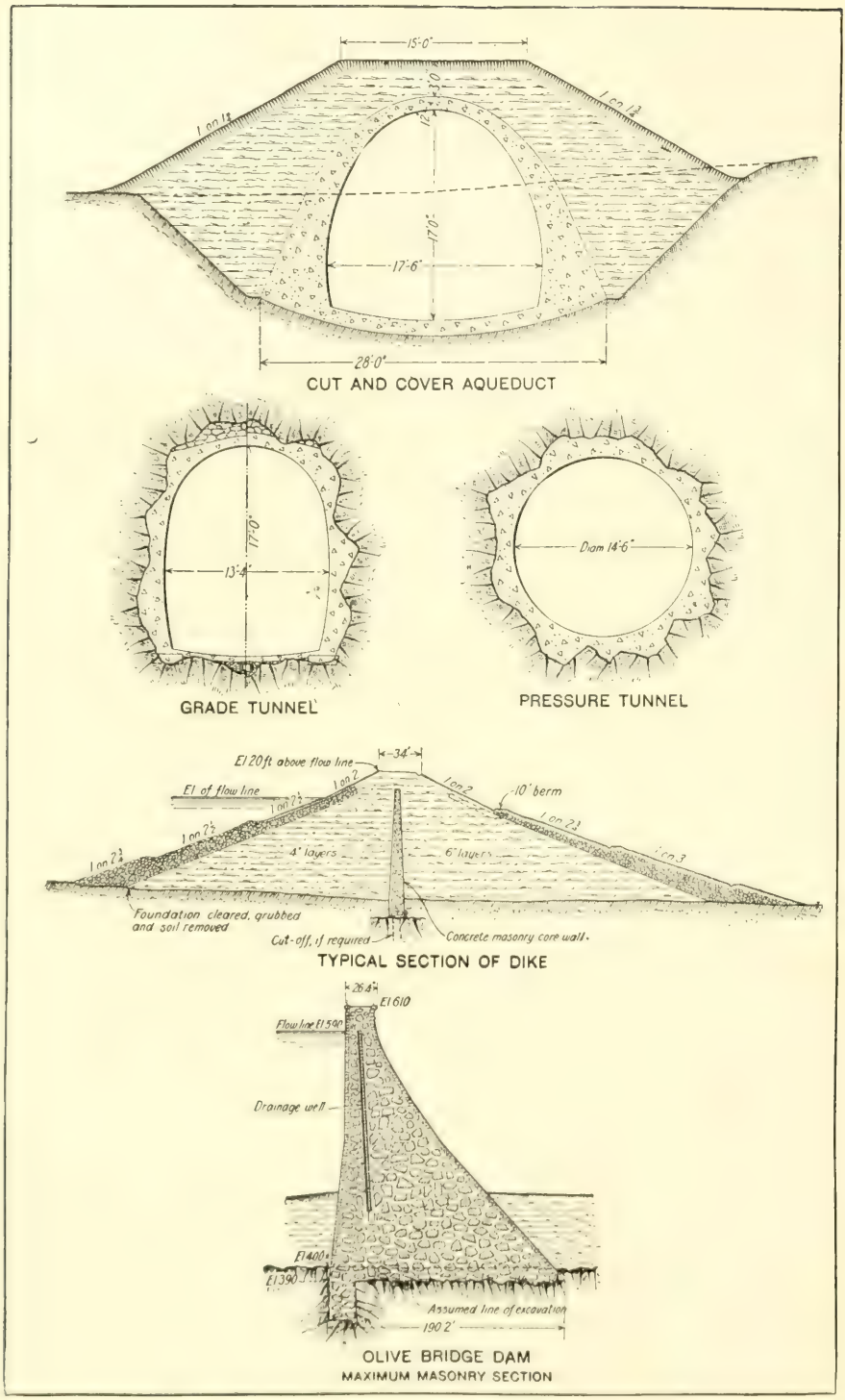


Fig. 5. Catskill Water System. Some typical structures

smaller camps in outlying parts of the reservoir work.

Throughout the work attention has been given to so treating the permanent structures and the spoil that the operations will result in blending the work with the general features of the country, so as to make pleasing pictures at all conspicuous points instead of the eyesores which have been so often created by public works. To this end, extensive planting and forestry operations are planned, and desirable existing growths are protected as far as possible. Nurseries for the propagation of forest trees are already established. The scarcity of top-soil in some places along the aqueduct presents a considerable problem in obtaining and maintaining growths sufficient for protection of earth embankments. Experiments already made to determine suitable grass mixtures for various soil conditions give promise of satisfactory solution. Rock embankments and spoil dumps may be screened and beautified by a covering of vines growing in pockets of earth.

The first construction for eleven miles of aqueduct was awarded in March, 1907. In the three years following, contracts aggregating more than $70,000,000, for the reservoir work and all of the aqueduct down to the city line, were prepared and awarded. Up to the end of 1911, nearly $45,000,000 had been earned upon contracts in force, and construction was so advanced that it is probable water can, if necessary, be delivered from the Catskill Mountains into Croton Lake about the end of 1912. At the periods of most active construction during the past two years, about 16,000 mechanics and laborers have been employed by the contractors, and it is not anticipated that the force for the coming year will vary greatly from this. Some particularly noteworthy progress has been made: In October, 1909, a quantity of masonry exceeding 33,000 cubic yards was placed in Olive bridge dam; in September, 1910, the excavation of one of the headings of the Wallkill siphon was advanced 530½ feet which is believed to be the world's record for hard rock tunnel.

And so with such a large part of this great enterprise achieved, it may be felt that we are measurably approaching that end which Mayor McClellan had in mind when he said at the inauguration of construction June 20, 1907, ". . . when this great work, conceived in honesty, begun in honesty, and God willing, completed in honesty, shall be ministering to the health and the happiness of millions yet to come, then

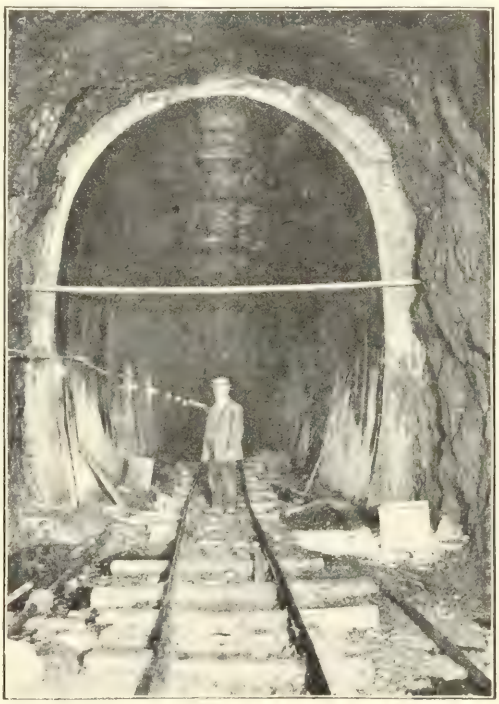


Fig. 6. Catskill Aqueduct. Bonticou grade tunnel, 17 feet high, 13 feet, 4 inches wide. End of completed arch lining

God grant that those who shall see it in the distant years may say—it does not matter how they were called who did this thing, or who they were or what they were: it is enough to know that they did their duty."

The Board of Water Supply which is building the Catskill works consists of three commissioners, Charles Strauss, Charles N. Chadwick and John F. Galvin, the first named, president.

THE FOURTH DIMENSION AS A TEXT

THE REALM OF ANALOGY WHICH IS STORED WITH CREATIONS OF MATHEMATICAL IMAGERY USEFUL ONLY TO THE SCIENTIST IN CORRELATING PHENOMENA

BY E. B. WILSON

To ATTEMPT to write a popular article on any scientific subject is taking one's scientific reputation rather lightly. For the things that are interesting are not true, and the things that are true are not interesting. The reason for this is that sane scientific truth lies not so much in facts as in points of view. The popular reader, be he never so well educated, is apt to be expectant of some startling fact and impatient of a qualified point of view.

Contrary to Newton's famous "hypotheses non fingo," the scientist is always making hypotheses, setting up theories, formulating models of one sort or another, to aid him in correlating known phenomena and to suggest to him new relations. Some of these hypotheses are wildly speculative, some of the theories are largely mathematical, many of the models are exceedingly gross and admittedly far removed from reality. All of these, in their interesting details, are temporary rather than permanent.

The reader who wishes to experience thrills (or the editor or writer who wishes him to) may revel in the wild hypothesis or gloat over the crude model with a feeling of satisfaction that he is up to date in science; and yet he may actually be getting further from the position of the true scientist than if he had never dabbled with these matters, unless he bears constantly in mind the vital point of view that hypotheses are only good, theories are only useful, and models are only valuable first, in so far as they are serviceable in correlating phenomena, and second, in so far as their manner of failure to correlate other phenomena may be suggestive of advisable changes in them.

Such a statement as this needs particularly to be emphasized by publications of general circulation like SCIENCE CONSPECTUS and *Popular Science Monthly*.

Apparently the fourth dimension is a subject of feverish popular curiosity. If a young lad, precocious in mathematics as in other things, discovers for himself a few theorems in four dimensional geometry, well known and evident to the trained mathematician, he is headlined all over the country as revealing new and marvelous doctrines to our learned geometers; and the interest in the fourth dimension becomes even more breathless. And yet, when regarded scientifically, the subject is uncommonly devoid of possible popular interest.

Mention the fourth dimension to a class of freshmen or sophomores, and the response is immediate though not unanimous; some listen reverently with bated breath, others smile incredulously and derisively. Both attitudes are wrong; we are not in the presence of a marvel or a fake, but merely witnessing the two habitual manifestations of ignorance, fright and persecution. The other topic that produces similar, though less marked symptoms in a class of undergraduates is "infinity," which for the mathematician is a subject much more interesting and difficult and necessary than the fourth dimension.

Some, if not most, of the blame for the wrong attitude of the public toward the fourth dimension must be laid at the door of mathematicians who have written on the subject for popular consumption. It is particularly true here that what is interesting is untrue and what is true is uninteresting. To be interesting is essential to the publicist. Hence the eclipse of truth

As, however, I am resolved to be as truthful as possible, I am indifferent to being deadly dull.

In the analytic geometry of the freshman year, and nowadays often in the algebra of the high school, the student learns to interpret the linear equation

$$ax+by+c=0$$

as a straight line. He learns that the solution of two such equations represents the point of intersection of the corresponding lines, and that the algebraic condition that the two equations cannot be solved simultaneously is equivalent geometrically to the statement that the lines do not meet, that is, are parallel.

In algebra he is also familiar with the linear equation

$$ax+by+cz=d$$

in three unknowns, and knows that ordinarily three such equations can be solved simultaneously. In solid analytic geometry he learns that the linear equation represents a plane, and that the algebraic solution of three simultaneous equations is equivalent geometrically to finding the point of intersection of three planes.

The correlation between the algebraic and geometric statements may be pushed a long way. Thus, if the three planes are parallel to a line so as to form the faces of a triangular prism, instead of a triedral angle, the planes have no point in common; the equations would then have no simultaneous solution. On the other hand, if the planes all pass through a line, they have an infinity of points in common; algebraically the three corresponding linear equations have an infinity of simultaneous solutions instead of merely one.

It must be apparent that a great deal of interest is added to the algebra of linear equations in two or three variables when the equations are interpreted as lines or planes as the case may be. Now suppose one had to deal with an equation

$$ax+by+cz+dw=e$$

in four unknowns. Here no geometric interpretation appears evident. For if we would represent a set of values (x, y, z, w) of the variables as a point, in a way analogous to our former representation of (x, y) or (x, y, z), we should have to have four dimensions. Now we do not have four dimensions. Hence we cannot make any such pictorial representation.

It may be, however, that we have become so thoroughly accustomed to speak of the pair of values (x, y) as a point in the plane and of the linear equation in x, y as a line, and of the triad of values (x, y, z) as a point in space and of the linear equation in x, y, z as a plane, that we cannot give up the geometric method of speaking. Thus we go right on talking with geometric words, saying that the set of values (x, y, z, w) is a point and that the linear equation in x, y, z, w is a planoid. But we should clearly recognize that if we do this, we are no longer speaking geometrically in the strict sense of the word, but merely analogically, because we have not four dimensions in space.

Powerful is the grip of figurative language. If we use analogy enough, we will find ourselves coming to believe in the existence of the analogue. By talking long enough as if there were four dimensions, we come to the belief that there are four. If we have to deal with equations in five or six or ten unknowns we shall likewise come to talk of, then to believe in, five or six or ten dimensions. The fact that we are merely talking words of which we have no very keen visualization does not bother us very much; we are accustomed to it in our discussions of art, economics, literature, politics, education, and everything else, to such an extent that it is no serious inconvenience in mathematics. It is faith not reason that brings action; we fight for catch-words and mottos, we arbitrate reasons.

Although the first stage of our use of four or more dimensions may thus be rather loose and vague analogy, we may reach a second stage by inverting the relation between algebra and geometry. Whereas we began in the two simpler cases by interpreting the algebraic elements as geometric elements in plane or space, we may now define the geometric

elements of higher dimensions in terms of the algebraic. Thus by definition a set of values (x, y, z, w) shall be called a point in four dimensional space, and by definition the said four dimensional space shall consist of the totality of such points or sets of values. Persons who desire to avoid the use of the term space in this connection often employ the word manifold.

We may carry our definitions further. The totality of sets of values (x, y, z, w) which satisfy a linear equation in x, y, z, w, may by definition be said to form a planoid. The values $(x, 0, 0, 0)$, for varying x, will be said to trace the X-axis; the values $(0, 0, 0, w)$, for varying w, trace the W-axis. The equation $w=0$ is said to be the planoid which represents the three dimensional space of x, y, z; the two simultaneous equations $w=0$, $y=0$ represent the plane of x and z. And so on. Any person who knows the formulas for the distance between two points in two dimensions and in three dimensions will have no difficulty in extending those formulas by analogy to obtain the expression which by definition shall be the distance between two points in four, or in any number of dimensions; and so with a great variety of formulas in analytic geometry.

In this way we construct by definition a four dimensional space or manifold with all sorts of elements in it. This, however, does not imply the existence of any such space in a physical, as distinguished from a conceptual mathematical sense. It does not mean that the visualization of that space and the elements in it is any less vague than in the first stage of mere verbal analogy. The advance consists merely in the definiteness of a logical nature which has been gained by actually giving the definitions. Instead of believing in some undefined fourth dimension in which we are interpreting our algebra, we see clearly that our so-called space of four dimensions is really defined from our algebra.

One might readily ask: What use is this space thus defined? How by mere definition from algebra can one obtain a geometry that contains anything more than was contained originally in the algebra? Logically you do not obtain anything new; analogically you have perpetuated a graphic phraseology which may suggest, by analogy, certain relations which would not so readily be suggested by the purely algebraic form of statement. And this is precisely the use of the space that has been defined. Logic is only the prose of mathematics; imagery is its poetry, and there is often more inspiration in a vague impressionistic poem than in the clearest prose.

We have spoken of the algebraic derivation of the fourth and higher dimensions. This was perhaps the first, it is undoubtedly the most developed aspect of the subject. Long treatises, intelligible only to the professional mathematician, have been written about it. Here at the Institute within a year Professor C. L. E. Moore and Doctors H. B. Phillips and J. Lipke, of our mathematical department, have published original investigations concerning higher dimensions, and some years ago I did as much myself. It is a thoroughly creditable field of research in pure mathematics—not in physics, nor in psychics.

We must not altogether omit mention of another point of view which, in contrast with the algebraic, may be called the logical or postulational method of constructing a geometry of higher dimensions. Let us first observe that we found plane geometry upon a certain (or perhaps a rather uncertain) set of axioms or postulates. When we come to study solid geometry we find a few additional or different axioms to complete the former list and adjust it to three dimensions. Now suppose that we lay down a set of postulates which is a sort of extension and alteration of our list for space in such a manner that the elements called points could not all be represented as points in three dimensional space. Then, if our list of postulates or axioms is free from self-contradiction, we can logically build up a geometry upon it as a basis.

For we must remember that although in two and three dimensions we actually draw figures and demonstrate our theorems from them, the real proof of the

theorem is independent of the figure and stands or falls solely by the perfection or imperfection of the logic by which the successive conclusions are drawn from the premises, and these premises are either previously demonstrated theorems or the axioms or postulates. Thus by pure logic we can build up a system of geometry for two and for three dimensions wholly without figures, provided only that our postulates suit the plane and space.

In a similar manner a number of non-Euclidean geometries have been built up from assumptions differing in one way or another from those of Euclid. Hence in this way, too, we could construct a four dimensional geometry. But here again we have no more a real physical space of four dimensions than we had from our algebraic point of view. As there it was all a question of definition from algebra, so here it is all a question of logical deduction from assumed propositions called postulates. In both cases it is a mathematical game that we play with the aid of geometric analogy; and we call it geometry because we use the language of geometry and feel the analogy so keenly that the analogue seems almost to attain objective reality.

We say seems almost to attain objective reality. For to the pure mathematician no more than to the man in the street is that reality attained. No one has any clear real visualization of a fourth dimension added to length and breadth and depth. It is the thorough training in algebra, the great facility in abstract logic, and above all a hypertrophied sense of analogy which enable the mathematician to thread his way safely through the mazes of four, and higher, dimensional geometry, even though those geometries are more complicated than ordinary solid geometry. For all that a mathematician may know about the fourth dimension he can no more get out of a closed box than can any one else.

What is the fourth dimension? There is none, in the sense in which this question is usually asked. Mathematically it is a sort of vague analogy, or a geometric phraseology applied to algebra, or a body of logical deduction. Not very exciting, all this.

The external space in which we live is geometrically three dimensional. Yet the world in which we move is in one sense at least four dimensional. For we need to know not only "where" but "when." We need not only the three coördinates (x, y, z) of position in our three dimensional space; we need also the additional variable t to denote the time. In order to specify the location of a particle in time and in space we have to attach to the particle four variables (x, y, z, t). We can therefore speak of this complete designation as a point in four dimensions.

Indeed in texts on mechanics in studying the motion of a particle on a straight line where the distance of the particle from a given point of the line may be represented by x and varies with the time t, it is often found convenient to plot the relation between x and t as a curve in a plane, the plane of the variables x and t. This curve is not the locus of the particle, which is moving in a straight line, but it serves to represent graphically the relation between distance and time. In a similar manner the motion of particles in three dimensional space could be represented by curves in the four dimensional manifold or space of x, y, z, t.

This may seem very artificial, and it can hardly be said to be useful in elementary mechanics, where the student has difficulties enough without worrying about four dimensional geometry. But it is worthy of note that from a mathematical point of view this representation of space and time in a combined four dimensional manifold or space forms the basis of the simplest statement of that new fundamental physical Principle of Relativity, which Professor Comstock has been explaining to readers of Science Conspectus. It is therefore not at all improbable that the time is close at hand when physicists, in addition to mathematicians, will have to become accustomed to the use of four dimensions. That is a question upon which Professor G. N. Lewis and I are hard at work.

GEOLOGY OF THE RHINE VALLEY

DESCRIPTIVE SKETCH OF THE FIVE GRAND GEOLOGICAL DIVISIONS OF THE RHINE EXTENDING FROM ITS SOURCE IN SWITZERLAND TO THE NORTH SEA

BY H. W. SHIMER

The course of the Rhine from its rise in southern Switzerland, through Germany and Holland, to the North Sea consists of five grand divisions. The Alpine division extends from the beginning of the Vorder Rhine on the heights east of Andermatt to Lake Constance, a distance of about 100 miles. It is here a small stream with numberless milk-white cascades and raging falls, running amid rocky defiles and fed by snow-clad mountains. The Great Swiss Valley division with a length of 100 miles from Lake Constance to Basel flows between comparatively low banks through a portion of the great lowland area of Switzerland. Its course is marked by few cascades and falls, the only one of note being the celebrated Falls of the Rhine near Schaffhausen. Since these falls were not mentioned by the Roman writers, who were familiar with this region, it has been suggested that the Falls were not then in existence, but that the river was then cutting through the loose glacial drift which filled the valley and reached the bedded rock of Jurassic limestone over which the river now falls only in post-Roman times. Thick deposits of glacial drift form part of the river banks from above the falls to far below them. Just above the falls the river has a width of 375 feet.

The third, or Graben division of the Rhine, extends from Basel to Mainz, a distance of about 200 miles increasing in width from 600 feet at Basel to 1500 feet at Mainz. It forms the handle of which the two earlier divisions are the hook in a very perfect figure five or button-hook. In this Graben division, to use the German term for a down-faulted block of the earth's crust, the Rhine flows over the top of the keystone which has fallen out of the elongate earth arch extending from Basel to Mainz. This keystone had an average width of twenty miles and over this flat surface the river only now meanders with not even a rapid to mar its even course. At the sides of this valley the hills rise quite suddenly to a height of 1000 to 1500 feet. As the northeastern continuation of this Graben has been partly filled with volcanic deposits the Rhine bends northwards over the region of the slate mountains, and into these rather level uplands it has cut a narrow gorge about 1500 feet wide and 500 feet deep. This, the fourth, or Gorge division, extends from Mainz to Bonn, a distance of about 100 miles. The river is here swift, with many rocks exposed in its bed. The scenery of this division is very celebrated; the river is bordered by precipitous cliffs for nearly this entire length; with here and there the houses of some small village clustered at their base or clinging to their steep flanks. The southward or southwestward facing slopes are covered with vineyards, the fruit of which goes largely to the making of the celebrated Rhine wines; the other colder slopes are clad in the green of dark forests. Clinging to the edge of the gorge or perched upon outlying pinnacles of rock, are the celebrated Castles of the Rhine, those strongholds of the ancient robber barons, from which they could make raids upon the commerce on the river below, the only highway through this region,—or levy their scarcely more legitimate toll.

The Gorge division of the Rhine suggests the Hudson River of New York in its passage through the Highlands from Newburgh to Peekskill. The Rhine, however, possesses an historic interest

North Sea
P
E
C
E
Q
E
P
P
M
M
M

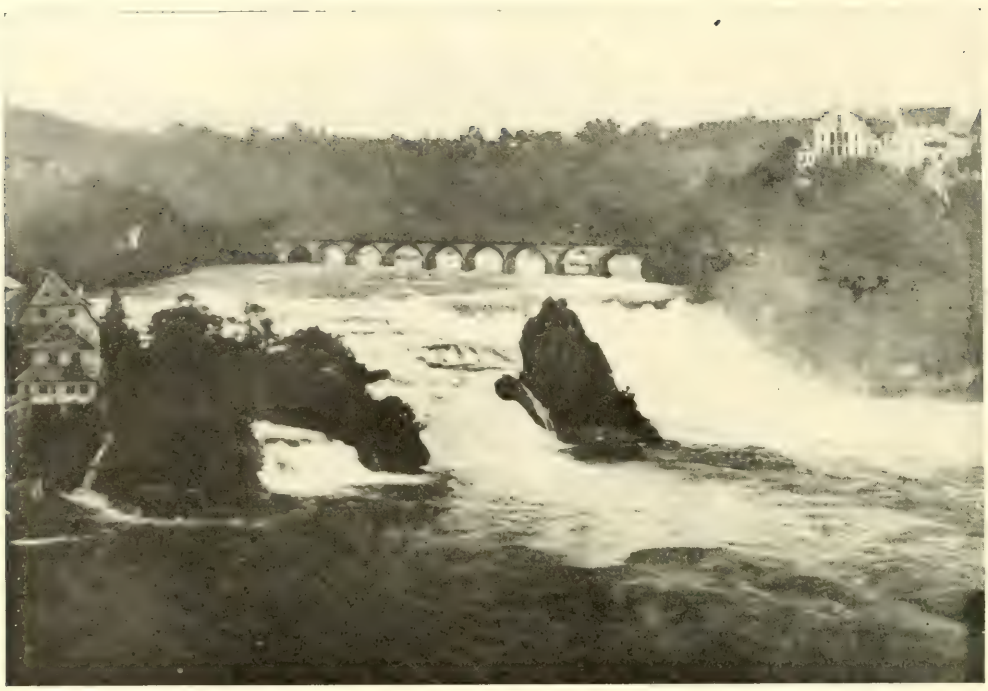


Fig. 2. Falls of the Rhine near Schaffhausen, Switzerland

and devoid of a solid rock bed, with a breadth of half a mile at its entrance into Holland. To the south lies the Great Belgian fault extending from near Liege westward. Along this line the land to the north has sunk, enabling the sea in earlier times to extend far inland over this region, but now again excluded by the mud which the Rhine is continually carrying with it.

During this long journey the Rhine descends over 6,000 feet. At Tschermut, some distance below its source, its height above sea level is 5,400 feet. Thence it descends rapidly to Chur (2,000 feet). At the end of the Swiss Valley division at Basel it has descended to 800 feet above sea level, at the end of the Graben division at Mainz to 200 feet, and at the end of the gorge at Bonn to 150 feet.

The embryonic Rhine grows rapidly by rivulet accretion and makes its way past its junction with the Hinter Rhine near Chur, on to its entrance into the broader, down-faulted valley at Vaduz. Throughout this portion of its course it is a rapid, foaming torrent, running at times through narrow, vertically sided canyons, and again, in regions of softer rocks, broadening into inhabitable valleys. The down-faulted valley in which the Rhine flows from Vaduz to the Lake of Constance extends north between high mountains, and averages in width some six miles. It is very rugged at its southern end, but becomes more level and hence more cultivated toward the north until, at the Lake of Constance, not only is the valley level, but the bordering mountains have become low and rounded. The Rhine now enters the Great Swiss Valley, expanding into the Lake of Constance, one of the four great lakes of Switzerland which lie in the valley.

In this large settling tank it loses all of the sand and mud torn from the Alpine rocks, which it still retained after its sluggish trip down through the valley to the south. The delta, resulting from the deposition of this sediment, is grad-

ually filling up the lake, and has already grown northward some fifteen miles, producing ideal farm land.

The shores of the lake are low, rounded hills, like the entire Swiss Valley

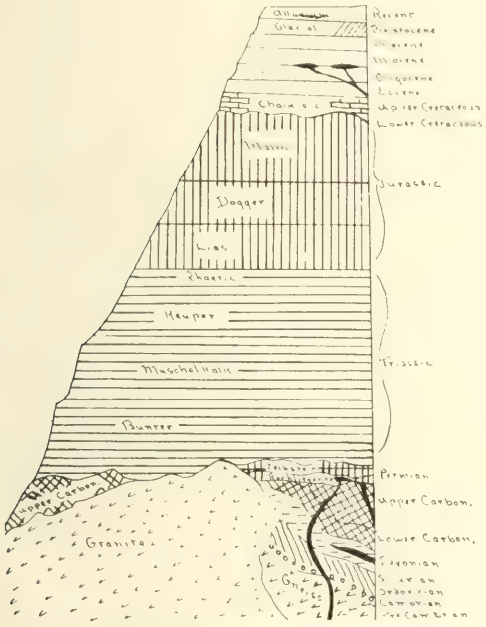


Fig. 3. The general succession of strata in the Rhine valley

and its eastward continuation to Vienna; so that the lines

> "Girt round with rugged mountains
> The fair Lake Constance lies"

can scarcely, even through the courtesy of poetic license, be applied to the region. At its exit from the lake the Rhine is very clear, but quickly picks up sand and mud as it hastens forward in its work of broadening and deepening its bed. Its shores remain comparatively low and rounded and its bottom consists of soft glacial sediment, except where, as at Schaffhausen, it leaps down over a bed of limestone (Fig. 2), and where, as at Laufenburg, it is cutting into the hard gneisses of a spur of the Black Forest. In this later part of its trip before reaching Basel, the hills are higher, formed of the Black Forest to the right and of the dying-out ranges of the Jura mountains to the left.

Though the Rhine river itself is a comparatively late development in geologic time, yet significant facts in its geologic career are found in the older history of the country over which it passes.

During the time of the Pre-Cambrian, the Cambrian, Ordovician, Silurian and Devonian, those regions which were under water received sediment, as Lake Constance or the seashores at present (Fig. 3). These sediments enclosed some of the shells or other remains of life then living, which are to us landmarks on the long road of evolution. A considerable amount of volcanic material was poured forth from the volcanoes of Devonian times. The lower and upper Carboniferous were periods of mountain building for all of central Europe. Some of the roots of these mountains, reélevated, form the present Black Forest, Vosges

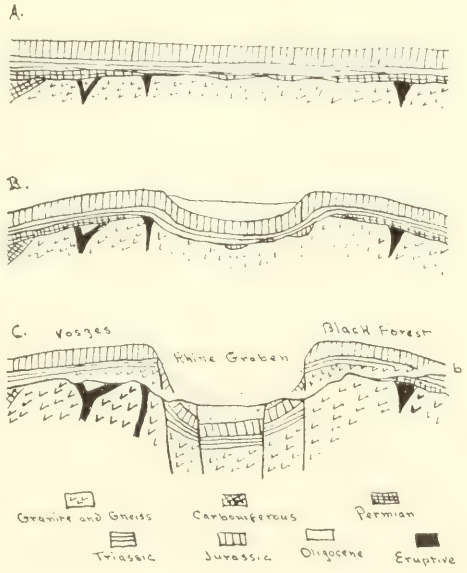


Fig. 4. The origin of the Rhine Graben. (Modified from Schmidt.) Vertical scale much exaggerated

A. At the end of the Jurassic.
B. At the end of the Oligocene.
C. At the end of the Miocene.
The line *a–b* represents the present surface of the land, the strata above having been removed by erosion.

Fig. 5. View of a portion of Heidelberg, from near the Castle. The Neckar River is in the foreground and the broad, flat Rhine Graben valley fades away in the background. The abrupt change from the elevated valley sides to the level Graben floor is well shown

and Slate Mountains. Accompanying this great upfolding of the earth's surface rocks, as is usually the case, was a widespread intrusion of igneous rocks such as granite. This granite is well exposed in the Odenwald, Vosges and Black Forest. These mountains were subjected to a long period of erosion, through the agency of wind and water. Some of the sediment thus gained was deposited upon the land by the rivers overflowing their banks on the way to the sea, and form what are now called the Permian and lowest Triassic (Bunter) rocks. Then the sea again invaded all of central Europe, remaining here until the end of Jurassic times, when it was withdrawn from most of what is now Europe, but returned again in the Upper Cretaceous. Each of these periods of sea transgression left sediment enclosing its own characteristic life remains.

During the Oligocene and Miocene the mountain-building forces focussed for the second time in central Europe, though mostly to the south of the ranges formed during the Carboniferous. They this time produced the present mountains surrounding the Mediterranean Sea, including the Alps, Juras, the Rhine Graben with its bordering hills and the Slate Mountains.

In the Lower Miocene period much volcanic activity occurred, producing the Eifel mountains and the Seven Mountains. During the Pleistocene, glaciers occupied most of the area under discussion, scouring loose rock from heights and depositing it in depressions, or at the ends of the glaciers, and damming drainage forming lakes and bogs.

The origin of the present form of the Graben division of the Rhine is shown in figure 4. The uppermost figure shows the Permian, Triassic, and Jurassic sediments resting horizontally upon the upturned and eroded gneisses and carboniferous strata and the intruded granites

Fig. 6. The Lorelei. A typical view of the narrow, steep-sided gorge of the Rhine and of the level plateau of the Slate Mountains, into which the river has cut

and other igneous rocks. About the close of the Oligocene (Fig. 4 B) this region was subjected to a horizontal compression which resulted in a low elongate dome with a north-south axis. As the central line of this dome was insufficiently supported there resulted a sagging in this area until finally this sinking block broke away from the rocks at the sides (Fig. 4 C and Fig. 5). The total depression of this block is about 3,000 feet.

The cities in or bordering the Rhine Graben have been celebrated since Roman times,—Freiburg, the doorway to the Black Forest, noted for its cathedral and university; Strassburg, in the middle of the perfectly flat Graben valley, with its large cathedral with the very complicated clock, its university and the many storks breeding upon the housetops, and Heidelberg with its most celebrated university and its thirteenth century castle. Worms and Mainz are both in the Graben valley, the former the city of the conference of *1521* under Emperor Charles V to discuss the heresy of Luther, and the capitol of the ancient Burgundian city credited with so conspicuous a part in the Niebelung adventures; for it was here that Hagen killed Siegfried for the Niebelung treasure and Kriemhild avenged her husband. Mainz is best known as the city of Gutenberg, the most credited inventor of movable type in printing.

Throughout the Graben valley the most used building stone is the brick red Bunter sandstone, since it is the most common bedded rock east and west of the Graben. Of it are built such conspicuous buildings as the Freiburg and Strassburg cathedrals and the Heidelberg Castle.

Beyond Mainz, after a short westward bending, the Rhine turning northward again enters at Bingen the narrow, meandering gorge through the Slate

THE SOCIETY OF ARTS OF THE MASSACHUSETTS INSTITUTE OF TECHNOLOGY

The Society of Arts was established as a department of the Institute by President Rogers in 1861. It is especially devoted to the general dissemination of scientific knowledge, and it aims to awaken and maintain an interest in the recent advances and practical application of the sciences.

Any person interested in the aims of the Society is eligible to membership.

The annual dues are $3.

RICHARD C. MACLAURIN, President of the Institute.
ISAAC W. LITCHFIELD, Secretary of the Society of Arts.

EXECUTIVE COMMITTEE

ELIHU THOMSON
JAMES P. MUNROE
THE PRESIDENT
THEODORE N. VAIL
CARROLL W. DOTEN
FREDERIC H. FAY

THE SECRETARY

BOARD OF PUBLICATION

D. F. COMSTOCK
SELSKAR M. GUNN
ELLWOOD B. SPEAR
LEWIS E. MOORE

I. W. LITCHFIELD, Editor

SCIENCE CONSPECTUS is published December, January, February, March and April.

Mountains. This and the Alpine division are its principal zones of destructive action, just as the other three divisions, especially the Delta Plain, are its zones of construction. The meandering course of the gorge through these mountains is the Rhine's medal of honor for vast work accomplished, that of wearing down, with the aid of wind and weather, and carrying away, particle by particle, those mountains raised during carboniferous time. It levelled them down to a plain, over which the river could wander almost at will, as it wanders now over its Delta plain. It at this time acquired these meanders which during Oligocene and later periods were impressed upon the slowly rising rocks beneath; the rise has been slow enough for the river to cut down its bed and not be deflected in another direction.

This downcutting work of the Rhine into the slowly rising country of the Slate Mountains has thus resulted in the formation of a narrow gorge (Fig. 6) in which the river is now working both to deepen and to widen its valley.

The level edge of the gorge as viewed from the bottom, or the still more impressive even sky-line as seen from the top of the gorge are the now raised floor of the plain upon which this portion of the Rhine acquired its meanders.

The ruined condition of the numerous castles along both sides of the gorge is mainly due to the activities of the generals of Louis XIV in 1689. Since that time several of the best preserved have been restored, but the vast majority still exist merely as crumbling ruins, ruins of intense interest, both historical and legendary.

At Neuwied the gorge suddenly widens, for it here enters the area of a small downfaulted block. This Neuwied basin has been partly filled with volcanic material, lava and ashes, but is still distinctly lower than its surrounding rim. To the west of this rise the low volcanic peaks of the Eifel Mountains, and a little farther down stream to the east rise the volcanic Seven Mountains, with Drachenfels the most conspicuous; both of these groups of hills are merely volcanic excrescences upon the Slate Mountains, for the plateau under each is the black, Devonian slate which gives name to the mountains.

Beyond Bonn the valley suddenly widens and the Delta plain division is reached. From there seaward the hills gradually become lower until floor-like Holland is reached, a country indebted to the Rhine for its rich soil, and, indeed, for its very existence. After traversing this level plain the Rhine through many mouths enters the North Sea.

THE LIGHT QUANTITY HYPOTHESIS

THE NEW IDEAS AS TO THE ATOMIC NATURE OF RADIANT ENERGY WHICH PROMISE SOLUTIONS OF MANY DIFFICULT PROBLEMS

BY D. F. COMSTOCK

WITHIN the last few years the idea has been gaining importance that the light radiated from a luminous body is not emitted continuously, but in small indivisible "atoms of energy." This notion is totally unexpected from the standpoint of a decade ago, but evidence of one form or another is piling up so fast that it appears at present highly probable that in the end it may prove to represent the truth.

The idea was first put forward by a physicist of international fame, Professor Max Planck, of the University of Berlin. He was led to this conclusion through his study of the so-called laws of radiation.

In order to make a discussion of this hypothesis at all clear, it is necessary to speak of the phenomena of radiation in general. The simplest type of radiation which we know is that which a so-called "black body" gives off when heated. Perhaps the simplest black body we could take would be a tin cup covered with lamp black on the outside and filled with hot water. This body gives off heat rays in all directions which, as far as we know, differ in no way whatever from light rays except that they are on the average of a lower frequency, *i.e.*, they bear the same qualitative relation to light rays that the lowest note in the piano scale bears to the highest. These rays do not affect the eye because the retina is not so constructed that it can detect such relatively slow vibrations. The laws of propagation of the waves and their general characteristics are apparently, however, exactly the same as those of light rays.

Now if we suppose the cup filled with something besides water and to be slowly heated, hotter and hotter, we should notice two significant changes in this radiation which spreads out in all directions from the cup. In the first place, as it gets hotter, *more energy* will be radiated in a unit of time, and second, such energy as is radiated will have a higher average frequency than before. Making a sound analogy, we might say that this corresponds to the sounds given off being *louder* and of *higher pitch*. If this heating process goes on indefinitely the frequency will soon be high enough so that the retina of the eye will be affected by the rays and the object will be "red hot."

Now the exact way in which the radiation of a black body changes with increasing temperature, has been studied very carefully and several theoretical formulæ have been found which agree more or less closely with experimental results. Perhaps the most successful of these is the so-called formula of Wien which was derived from the fundamental conceptions of atomic theory. It is almost certainly true that the radiation from a hot body is caused by the chaotic to-and-fro motion of the atoms or molecules of which the substance is composed, and the general distribution of motion among the vibrating molecules or atoms is pretty well known at the present time. Wien obtained his formula by supposing that each molecule radiated energy in a way which depended only on its velocity at the instant in question.

Now although Wien's formula certainly contains some element of truth, it fails conspicuously at high temperatures. This failure has been realized for a number of years, but no suggestion was forthcoming in regard to *why* it failed.

This failure of Wien's formula is by no means an isolated fact of small importance. The ablest thinkers in theoretical

physics all over the world have considered at great length the theory of radiation, and although there has been more or less complete agreement among them, their results are not accurately in agreement with the results of experiment. Indeed a decade ago it was generally agreed that something was wrong with the fundamental notions underlying the theory.

In about 1905, however, Professor Planck came forward with an entirely new hypothesis. By one of the mysterious mutations which we call "inspirations of genius," he came to the conclusion that if we were to get a theory consistent with experiment, we must assume that the atoms do not radiate energy continuously, *but radiate only in small discrete quantities, "atoms of energy" one might say.* From this point of view the oscillating part of an atom cannot possess *any* amount of energy, but only an amount which is a definite multiple of a fundamental unit of energy.

This is an extraordinary assumption and is in a sense a sudden jump in physical theory, but Planck showed that when one developed this hypothesis by well-known and rigid methods, an equation was obtained which differed slightly from Wien's formula and which was much more hopeful in its form. As a matter of fact, careful experiments have shown that as accurately as measurements have been carried out, Planck's formula is exact for all temperatures.

It is an interesting and suggestive fact that Wien's formula appears as a special case of Planck's when the temperature is not too high. In other words, Planck's formula contains apparently all the truth that is in Wien's and enough more to make it an exact representation of the fact. It is also an interesting sidelight on the rapidity with which apparently remote scientific hypotheses may react on the industrial world, that Planck's formula is already beginning to have an important effect on interpreting the results of the so-called optical pyrometers so extensively used in measuring the high temperatures of furnaces.

So extraordinary is the assumption of discrete quantities of energy that were it only applicable to the theory of radiation, the conception would not be as impressive as it has grown to be within the last few years, but curiously enough there is totally independent experimental evidence for it. Other results seem to indicate that light and similar wave motions propagate in the form of units of energy.

It is a well-known fact in physics that if a current is passed through any vacuum tube in which the vacuum is very high, a stream of electrons proceeds from the negative terminal in the tube and travels in straight lines. This stream of electrons constitutes what we know as the cathode rays. When these rays strike any obstacle, X-rays are emitted from the point struck just as sound would be emitted from a barn door struck by a shower of stones. These X-rays are considered to be of the wave-motion type of disturbance and not a stream of particles. The shower-of-stones-sound-analogy is therefore quite accurate, since sound is a wave motion. The analogy, however, fails of further application, for it is found that when these X-rays strike a metal they give rise to a stream of cathode rays (*i. e.*, a stream of electrons) which are called the secondary cathode rays and these cathode rays give rise to other X-rays. If the stone analogy were to be complete, the sound from the point struck by the stone would have to cause a stream of stones to come out of any substance which the sound struck.

Now the curious fact noticed about these electrons which spring out of a metal when it is struck by X-rays is that their maximum speed does not seem to depend on how intense the X-rays are, nor does it depend on the nature of the metal struck by them. If a piece of metal is taken farther away from the source of rays, so that the energy of the rays falling on it is less, it is found that fewer electrons come out of the metal in a unit time, but those that do come out have the same maximum velocity that they had when the metal was nearer.

Now a little thought will show that this result is totally inexplainable on the older ideas of radiant energy, for the

energy of the outcoming electrons is evidently derived from the energy of the striking X-rays, and as this energy spreads out indefinitely and gets weaker, it is to be expected that all effects produced by the energy would slowly dwindle away. This is not true, however; the emitted electrons come out with the same maximum speed as when far more energy struck them.

Now on the "light quantity hypothesis" the results are quite clear, for if the energy of the X-rays is really in the form of little particles of energy, then at greater distances from the source of the rays, the only difference is that the particles would be farther apart on the average. They are spread out more, but each has the same amount of energy and each is, therefore, capable of giving an impulse of the same strength to the electron in the metal which it happens to strike as it would have given had the metal been nearer; so that the experimental results totally inexplainable on the older idea of continuous energy radiation become readily explained when this "light quantity hypothesis" is applied.

Besides these two rather striking examples of the evidence for the light quantity hypothesis there are a number of others in which it is either definitely suggested by experiments or dimly foreshadowed. One set of results which seem to promise evidence in favor of the hypothesis are obtained in modern low temperature research. As is well known, the theoretical limit in diminishing temperature is the so-called "absolute zero." This is the temperature at which all atomic energy, or molecular energy of vibration would cease and is located at approximately 273 C. degrees below zero or 460 degrees below zero Fahrenheit. It is only very recently that temperatures at all approximating the absolute zero have been obtained, but now we have results on the electrical resistance of platinum wire measured at $1\frac{1}{2}$ degrees C. above the absolute zero. At this temperature, air and even hydrogen are solid.

Now at these very low temperatures there are certain unexpected anomalies in both electrical and heat phenomena. The so-called specific heat of substances, which from the older ideas should approach a certain definite constant as the temperature approaches the absolute zero, changes in a quite unexpected way as the temperature diminishes, for at these very low values it becomes so rapidly less as to approach zero instead of the constant finite value as above mentioned. It is very difficult to get any explanation of these low temperature anomalies on the older ideas of continuous energy distribution. On the energy quantity hypothesis, however, the results, while not yet worked out sufficiently to be called absolutely certain, are nevertheless very suggestive and promising.

Even in the domain of fluorescence an obscure question seems to be on the point of being cleared up by light quantity ideas, for it is well known in general, that fluorescent light is nearly always of lower frequency than the light which causes the fluorescence. This is in line with the new ideas, for although not yet mentioned in this paper, *the so-called atoms of energy are not all of the same size, but are larger in proportion to the frequency of light*, so that the size of the "atoms" corresponding to blue light is greater than the size corresponding to red light, and it is clear, therefore, that when a body fluoresces under stimulation from light of any color, it cannot give off larger light atoms (*i. e.*, bluer light) than it receives from the stimulating light; whereas it is perfectly conceivable that through some type of complex transformation, some of the energy might be left in a body and the energy quantities in the fluorescent light might be smaller (*i. e.*, the fluorescent light might be redder).

The light quantity hypothesis has not by any means been worked out so completely yet that its position and possibilities are well defined, but it seems at present full of promise and it is being used more and more by physicists throughout the world in explaining phenomena hitherto mysterious, both in the realm of radiation and in that of electricity.

THE PHYSIOLOGY OF EMOTION

PURPOSEFUL ELEMENTS IN THE BODILY CHANGES WHICH ATTEND EXCITEMENT—HOW MUSCULAR RE ENFORCEMENT FOR EMERGENCIES IS SECURED

BY PERCY G. STILES

THE physiologist, in contrast to the psychologist, looks at the features of human life objectively. Often he profits by adopting the other point of view, sometimes he finds that he has passed over to it when he did not mean to do so, but when he is strictly within his own province he regards a man as a mechanism and his brain as a collection of reflex arcs. Seen in this light the episodes of experience are recognized as adaptations, more or less successful, to changing external conditions. This is even the case with those emotional occasions which to our every-day thinking are essentially mental phenomena. The biological *raison d'être* of emotions—or of the general state of the body which attends them—has just been made clearer than ever before by the announcement of certain physiological discoveries. For these we are indebted to the ingenuity and insight of Doctor Walter B. Cannon.

While we commonly speak of the bodily conditions which are observed in connection with anger or terror as resulting from the mental state we must consider that we have no right to assume any such relation. All that we can safely say is that one is the accompaniment of the other. The James-Lange theory of emotions makes the feeling the outcome of the characteristic muscular tension; one feels anger because the hands are clenched and the forehead creased. Happily the physiologist need not pass upon the question as to whether the feeling or the bodily action is primary. His concern is to find out whether the welfare of the organism is served by the process.

The more obvious concomitants of strong emotion include the familiar muscular adjustments which produce suggestive postures and facial expressions, the changes in the breathing, and the disturbances of the heart's beating. Equally evident are the flushing and paling of the skin which show that the vaso-motor system is involved. That the glands share in the awakening is plain from frequent instances of sweating and salivation as well as from the shedding of tears. Scientific analysis has made it apparent that some of the manifestations of emotion are inhibitions; that is to say, that there is not an indiscriminate stirring up of all the tissues to increased activity but that there are restraints imposed upon some organs. So we may have momentary standstill of the heart, brief arrest of breathing, suppression of secretion instead of stimulation.

Doctor Cannon himself in earlier contributions has shown that the movements of the stomach of the cat may be interrupted when the animal is agitated. Pawlow, the Russian experimenter, has proved just as decisively that the secretion of the gastric glands may be withheld when circumstances interfere with the enjoyment of a meal. Clinical experience teaches that the observations made upon the lower animals are valid for human beings. It has been natural to emphasize the potency for mischief which is incidental to such inhibitions. We cannot yet say of every manifestation of emotion that it is surely an adjustment for the advantage of the individual in the existing emergency. But we can see a purposeful character in some elements of the process that formerly seemed meaningless.

Under primitive conditions of life the

feeling of fear coincides with circumstances which make flight the rational course of action. Rage is felt when the best move for the animal—or for the savage man—is an attack on a foe. Now whether to flee or to give battle the need of the moment is for the most complete command of muscular resources. Two features of the emotional reaction have been shown by Doctor Cannon to favor precisely this attainment. One of these is an increase of sugar in the blood. The other is the extra production of adrenalin, the active substance contributed to the circulation by the small organs known as the adrenal bodies.

A rise of sugar above the low but usually constant percentage in the blood is demonstrable after a terrifying experience both by direct measurements and by the occurrence of sugar in the urine, the sign of an overflow through the kidneys. The source of the sugar is doubtless the starch-like reserve called glycogen which is normally held in the cells of the liver and muscles in readiness at any time to undergo conversion to sugar and to enter the blood-stream. Why should the transformation of glycogen to sugar occur at an emotional crisis? Because, we believe, sugar is the most available fuel which can be utilized to supply the energy needed for muscular contraction.

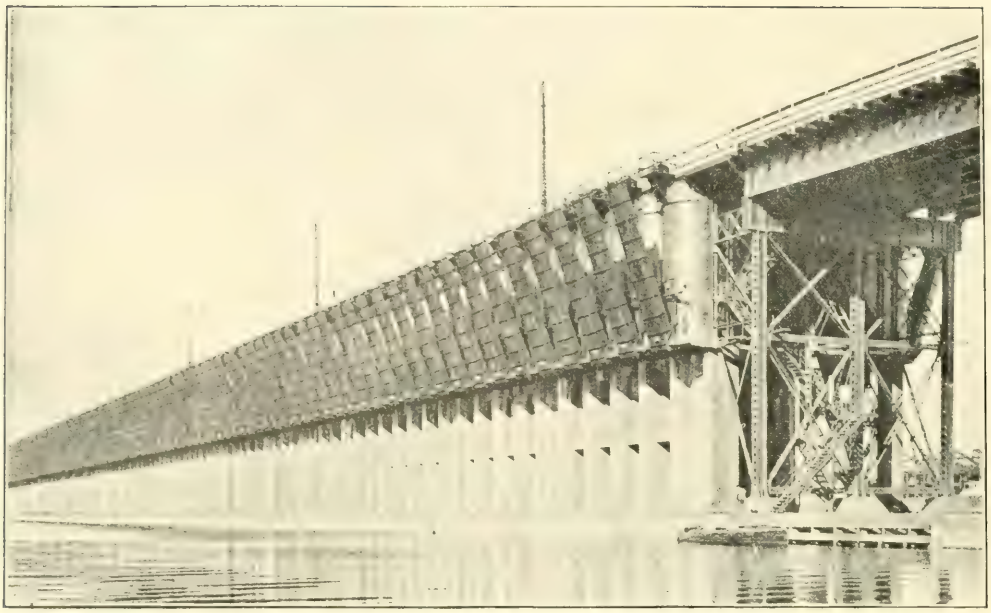
As to the value of the additional adrenalin turned loose at such a time a clear explanation is at hand. Doctor Cannon finds that it is an agent capable of postponing fatigue. If it is caused to circulate by artificial means through muscles which are flagging from continued work the renewing effect is very marked. There can be no question that when the adrenal bodies of an animal are played upon by the nervous system in moments of intense excitement the secretion which they discharge to the blood has the same favorable influence. Exhaustion is delayed and for a while there is an exhibition of unlooked-for power. This would seem to be nothing more or less than the "strength of desperation" often referred to and now seen to have a physiological basis.

Many of the physical accompaniments of emotion can thus be held to be of service. The cardiac and vaso-motor changes are probably such as insure readiness for action. The dealing out of sugar to the blood provides abundantly for the demands about to be made on the muscles. Even the inhibition of the alimentary canal is, perhaps, an instance of economy in one quarter to sustain liberality in another. Finally the issuing of adrenalin to the tissues reminds one of the theory on which grog used to be served to sailors before a sea-fight. That is to say, the purpose is to get the most possible out of the existing equipment. It will be observed that these reactions fit aboriginal rather than civilized environments. The emergencies which arouse us are usually to be met with intelligent and temperate action rather than with physical conflict. It will also be noted that the profound after-effect of even a brief emotional tempest is just what we should expect from a process so far-reaching and inclusive in its sweep.

VEGETABLES AND TYPHOID FEVER

Recent experiments have demonstrated that fruits and vegetables may act as vehicles of typhoid fever to a rather surprising degree. Soil upon which lettuce and radishes were growing was inoculated with fecal material containing typhoid bacilli. Some of the plants were then kept indoors, being sprinkled from time to time to simulate rain, while others were allowed to grow in the open exposed to the elements. Examinations of the leaves and stems of these plants for typhoid bacilli were still successful after twenty-five days in the plants kept indoors, after thirty-one days in those kept out of doors part of the day, and after ten days in those exposed during the entire day. Bearing in mind the ordinary country methods of sewage disposal it is easy to understand how typhoid fever on a farm may be transmitted to city-dwellers by garden truck.

F. S., JR.



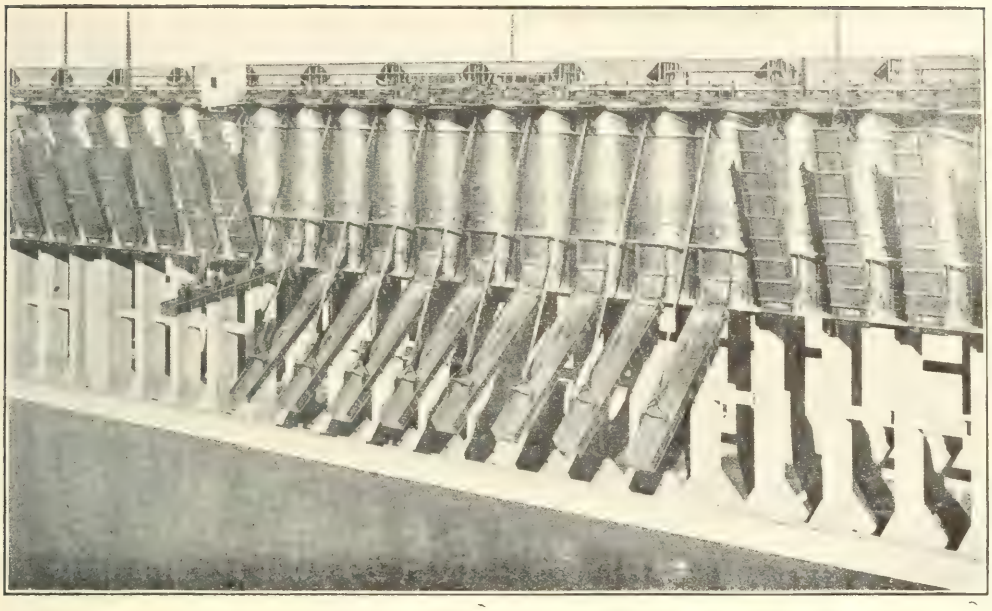
General View of the Great Northern Ore Dock at Allouez, Wis.
Courtesy *Engineering Record*

A REMARKABLE ORE-HANDLING DOCK

In order to care for its very heavy tonnage of ore from points on the Mesabi Range, the Great Northern Railroad has built the large ore dock at Allouez, Wis., on Lake Superior, which is illustrated on this page. This dock is the largest of its kind on the Great Lakes, being 1900 feet long, 71 feet wide over all, and having its top 75 feet above the mean water level. There are 151 pockets, or bins, for ore on each side, built to the standard spacing of 12 feet to fit the hatches of the ore-carrying vessels on the Lakes. Each of these bins has a capacity of 325 tons, and is designed to hold seven 46-ton carloads of ore, although as it is usually operated only six carloads are dumped in one pocket. The total capacity of the dock is 98,180 tons or 2,115 carloads, or 42 trains of 50 cars each. The dock is built for the purpose of handling ore, and not for storage, and has proved itself one of the most efficient loading docks on the lakes.

In operation a train is run upon one of the six tracks on top of the dock and the hopper-bottom ore cars are dumped into openings in the tops of the pockets. These openings are so spaced that a whole train may be dumped while standing in one place. The six tracks are used to distribute the ore evenly through the pockets and obviate trimming. The flow of the pockets slopes at an angle of 47 1-2 degrees with the horizontal in order to insure the free movement of the ore in flowing out to the vessels. As will be seen from the illustrations, the ends of the pockets are made semi-circular. This was done to prevent "arching" or clogging of the ore in the pockets, which would interfere with its flow. It has been found that these pockets empty practically completely, only about half a ton of ore remaining in them.

Soon after the completion of the dock 9,500 tons of ore (200 carloads) were loaded into a single vessel in 25 minutes.



Side View of the Dock with Ore Cars on the Structure. Courtesy *Engineering Record*

and at another time 8 vessels with an aggregate tonnage of 62,000 tons were loaded in six hours. Six of the largest ore boats can be loaded simultaneously. The spouts for loading the ore into vessels are seen in the second illustration. Some idea of their size may be obtained from the eight or nine men shown standing in one of the spouts. Each spout is 34 1-2 feet long, 5 1-2 feet wide at its upper end, and 4 feet wide at its lower end, the idea of the taper being to increase the friction of the ore against the sides in order to prevent its being shot into the vessels too violently. The spouts are raised by electric hoists and are not counterweighted. One 25-horse-power alternating current motor is provided for every ten spouts. Each spout may be operated independently, or several may be operated at once by the one motor. The connections of the shafting are such that in case a motor breaks down, the spouts worked by it may be handled by one of the adjacent motors. The spouts are lowered under control of the motor, and cannot drop suddenly.

The sliding doors of the bins are raised by hand winches, and once opened cannot be closed until the bin is empty.

As will be seen, massive concrete columns instead of the usual steel ones, are used to support the pockets. The columns rest on timber cribs, which are supported on piles. Transverse strength is secured by the partition walls of steel between the pockets. The approach is a long timber trestle, with 300 feet of steel trestle next to the dock. Expansion of the structure is taken care of by expansion joints at 120 feet intervals.

The dock is lighted by flaming arc lamps supported on steel posts 35 feet high and 192 feet apart. The use of the flaming arc lamps materially reduced the number of lamps required. L. E. M.

NEW MEMBERS OF THE SOCIETY

At the 678th meeting of the Society of Arts held February 20, the following applicants for membership were elected:

James T. Connor, 23 Englewood St., Dorchester, Mass.

P J. Doherty, 95 Milk St., Boston, Wass.

Roland B. Pendergast, 48 Beacon St., Boston, Mass.

Sarah E. Radway, 67 Beacon St., Boston, Mass.

POISONING BY ILLUMINATING GAS

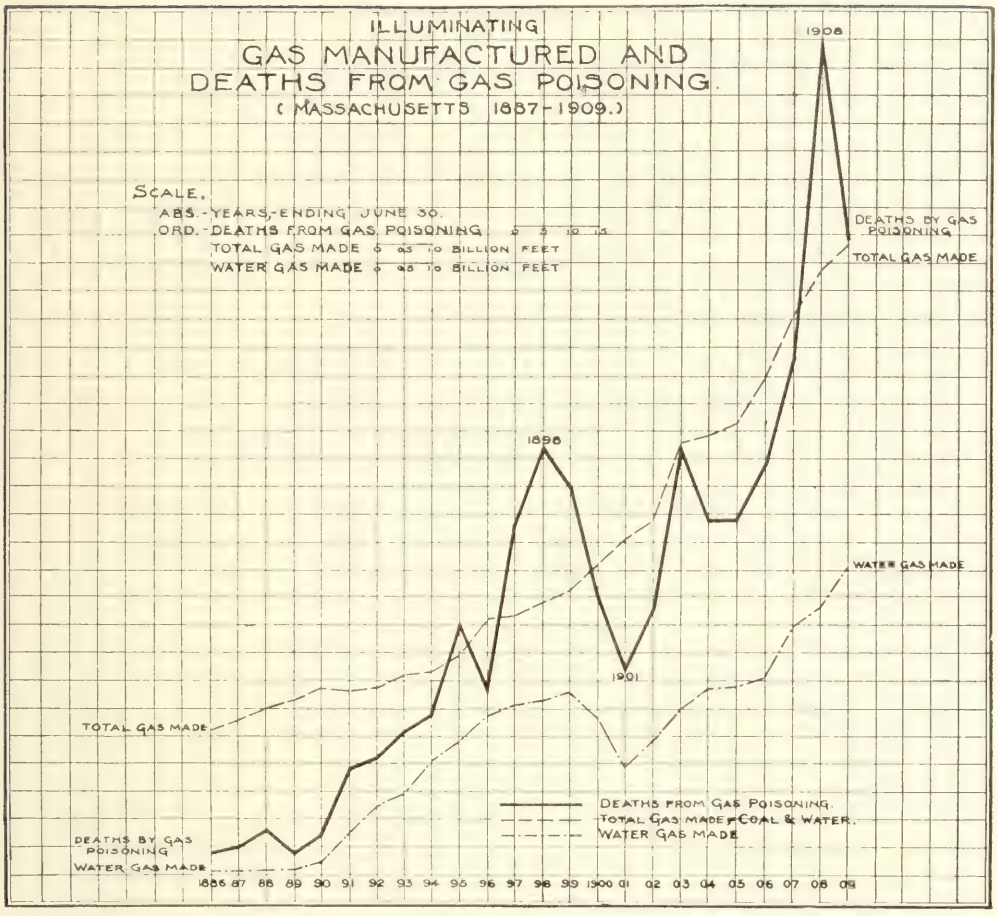
While the general public realizes that asphyxiation and death from illuminating gas poisoning are not uncommon, few comprehend the actual extent of the damage done and the preventability of the loss. Twenty-five or thirty years ago accidents of this kind were extremely rare, and deaths were almost unheard of; now they have become everyday events and the mortality rivals that from some of the more serious contagious diseases. In Massachusetts alone, in the twenty-year period ending with the year 1909 over 1200 persons died from gas poisoning. In New York City, according to the daily papers, there were reported to the coroner in the first six weeks of the present year seventy-five fatalities. The death-rate from this cause in Massachusetts has in some years exceeded that sometimes occurring from such widely feared and strenuously combatted diseases as measles and scarlet fever, and it is now higher than the rate for typhoid fever in many European and in some of the better American cities. The fact is that illuminating gas has come to be a serious, an increasingly serious, cause of death, and a point has been reached where it behooves health authorities and others interested in the subject to consider what steps can be taken to curtail this shocking mortality.

The deaths occur in a variety of ways. Sometimes they are cases of suicide,—a gas tube often being inserted in the mouth by the victim. Again it may be an undoubted accident, as when a family is asphyxiated even when there is no gas piping in the house, the gas entering through the cellar from a broken street main. Between these extremes there are cases of a doubtful character, in which it is practically impossible to decide whether the victim accidentally failed to completely close a gas cock or whether intent entered into the act. In the more than 1200 deaths investigated in Massachusetts the ratio between accidents and suicides was just about half and half.

An interesting point in connection with these deaths is their seasonal distribution, being relatively infrequent in the summer and most numerous in the cold winter months when the houses are more tightly closed, the days are shorter, and more gas is consequently used.

Demonstration of the preventability of gas poisoning has been one result of investigation of the subject. It would appear that practically the controlling factor is the nature of the gas distributed. In those localities where only the old-fashioned "coal-gas" is furnished, fatal cases are extremely rare; in places where the newer "water-gas" alone is made, deaths are frequent. The sudden rise of fatal gas poisoning about twenty-five years ago coincides with the discovery and introduction of "water-gas," and subsequent variations in the number of fatalities have, in Massachusetts at least, followed closely on corresponding variations in the production of this gas. An example in point is the experience of the year 1901. At that time the installation of the New England Gas & Coke Co.'s large plant at Everett resulted in a very considerable increase in the amount of "coal-gas" manufactured in the state, with a consequent decrease in the production of "water-gas." Despite the fact that in 1901 suicides in general ran high the result was at once manifest in a sharp drop in deaths from gas poisoning. These facts, as well as the general rise and fluctuation of the deaths, are brought out in the chart.

The controlling influence of "water-gas" is easily understood when its chemical composition is compared with that of "coal-gas." Whereas the former contains about 30 per cent. of carbon monoxide, well recognized as a highly poisonous gas, the latter contains only about 6 per cent. It has been shown by experiment that with gas escaping from a common fixture in an ordinary room this difference in composition makes that between comparative safety in the case of "coal-gas" and comparative


ILLUMINATING
GAS MANUFACTURED AND
DEATHS FROM GAS POISONING.
(MASSACHUSETTS 1887-1909.)
SCALE.
ABS.-YEARS,-ENDING JUNE 30.
ORD.-DEATHS FROM GAS POISONING 0 5 10 15
TOTAL GAS MADE 0 45 90 BILLION FEET
WATER GAS MADE 0 45 90 BILLION FEET
1908
1898
1901
DEATHS BY GAS POISONING
TOTAL GAS MADE
WATER GAS MADE
TOTAL GAS MADE
DEATHS BY GAS POISONING
WATER GAS MADE
DEATHS FROM GAS POISONING.
TOTAL GAS MADE FROM COAL & WATER.
WATER GAS MADE.
1886 87 88 89 90 91 92 93 94 95 96 97 98 99 1900 01 02 03 04 05 06 07 08 09

danger in the case of "water-gas." Evidently if the production of "water-gas" could be curtailed, or the allowable amount of carbon monoxide limited by law, as was the case prior to 1890, we would have a solution of the problem.

Just how relief will be obtained is not clear. To the simple remedy of forbidding the manufacture of "water-gas" there is the obvious objection that such a course would be unfair to the existing "water-gas" companies. On the other hand, the building of new plants might be restricted. It has been suggested that "water-gas" might be "denaturized" by the addition of some extremely irritating substance, so that the escape of the gas could not fail to be detected and sleeping persons be roused. This suggestion will become more helpful when some one has some satisfactory and really effective substance to suggest. Safety fixtures should also aid, but although some devices show promise, nothing of this sort really adequate has as yet been evolved. When all is said and done, unavoidable accidents are bound to occur and it seems inevitable that some reasonable limit must be set on the percentage of carbon monoxide. Gas poisoning which has already grown in civilized communities to startling proportions, is now steadily increasing, and yet it is almost wholly preventable. Is it not time, then, that the State should take up the matter and establish measures to prevent this great loss of human life?

The complete paper, giving details and illustrated by other charts can be found in the *Journal of Infectious Diseases*, Vol. IX, No. 3, 1911.

F. S., JR.

ADULTERATION IN MARASCHINO CHERRIES

One of the most interesting of the disclosures with regard to the adulteration of food products has been recently made through the investigation of the Maraschino cherry. It will be news to most people to hear that there are very few genuine Maraschino cherries on the American market today. This fact is due to the almost prohibitive cost in this country of the genuine Maraschino cherry which must be imported from Dalmatia and due also in a considerable degree to the demand of the American people for a pleasing appearance in their food:—a requirement which is not met by the real Maraschino cherry, a small, dark, and shrivelled object.

The article that generally passes for the Maraschino cherry has been evolved through several stages of experimentation. The original cherry was grown in Dalmatia as before stated, and this has not been cultivated elsewhere on a commercial scale. It derived its name from a place called Marasca, and was first used to make a liqueur. In time the Maraschino liqueur was put to purposes of flavoring, and finally the cherry itself was used to ornament drinks, ices, grape fruit and so on. Dissatisfaction with the appearance of the cherry led to an attempt to dye it, and the light green Maraschino cherry resulted. Then some one tried a red dye, and the color which we chiefly associate with the Maraschino cherry came into general use.

The under size of the genuine article, its high cost, and the difficulty of satisfying the increasing demand for Maraschino cherries, with college ices on the list of drinks at every soda fountain, naturally led to further experimentation to see if some satisfactory imitation could not be made.

From France a cherry large and attractive to the eye, known as the Bigarreaux cherry, is now exported to America to be used in the construction of Maraschino products. In most instances cherries are shipped packed in a solution of common salt and sulphurous acid that bleaches them during transportation. This sulphurous acid is removed on arrival by washing with water. The cherry is then dyed and after that artificially flavored with benzaldehyde or other substances.

At present it is required by law that none but the genuine cherry preserved in the original liqueur may be sold under the label "Maraschino Cherries." All others must be marked "Imitation Maraschino Cherries" although they may contain a large percentage of Maraschino liqueur.

Some danger exists in the consumption of the artificial varieties on the market today because sufficient care is not always exercised in washing out the acids used for and produced by the bleaching process. If properly prepared, however, the imitation cherry may be quite as healthful as the natural product.

E. B. S.

RINGWORM

The name of this well known skin disease is a misnomer, the trouble being caused not by a worm but by a little plant—one of the mould fungi. The disease is familiar to the layman as a small red ring an inch or so in diameter enclosing a clearer area, and occurring on the surface of the skin, frequently on the face and hands. The rings are formed by a gradual outgrowth from the center, the clear area being tissue which has recovered from the disease. The fungus parasite attacks principally the hairs, working down into the roots and spreading through the top layer of the skin. A number of varieties of ringworm exist, attacking both man and the lower animals, and some are communicable from the one to the other.

Another related fungus of a higher order is responsible for the so-called "fairy-rings" of toadstools observed in forests. Here again the fungus spreads from a center, branching out underneath the surface of the soil, and sending up its fruit bodies—the toadstools—in ever widening circles. The analogy between ringworm and fairy-rings applies both as to causal agent and manner of growth.

F. S., JR.

SCIENCE CONSPECTUS

VOL. II APRIL, 1912 NO. 5

THE MODERN AEROPLANE

THE PLAIN FACTS ABOUT AVIATION AND AEROPLANES TOLD BY A LICENSED AVIATOR AND EXPERT PERFORMER, WHO IS ALSO A SKILLED ENGINEER

BY EARLE L. OVINGTON

I PREFER to divide the development of the aeroplane into two periods; first period being before man made a sustained flight, and second period after sustained human flight was accomplished.

As far as history tells us, the opening of the theoretical period may be considered as starting with the glide of Oliver of Malmesburg, who, in the eleventh century, jumped from a tower in a glider and managed to glide 370 feet before breaking his leg.

In spite of the fact that it is generally considered that to the Wright brothers belongs the honor of the first flight in a heavier-than-air, power-driven machine, this is not the case. To be sure at Kitty Hawk, North Carolina, on December 15, 1903, the Wright brothers made a flight of 852 feet. As far back as October 9, 1890, however, Clement Ader, a Frenchman, flew 174 feet. As both of these flights came to an end on account of deficient lateral stability of the machine I do not consider them practical flights. The first real aeroplane flight of any consequence was that of the Wright brothers at Dayton, Ohio, on September 26, 1905, when they flew for eighteen minutes and covered a distance of eleven miles. It must, indeed, be a practical aeroplane which can accomplish such a feat. I consider, therefore, that the practical period of aviation commences with this latter flight of the Wright brothers.

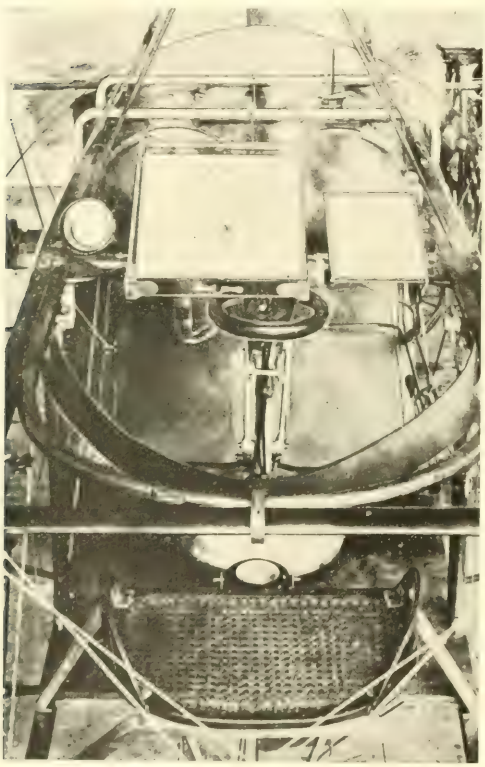
It is a peculiar fact, but nevertheless true, that during the first or theoretical period much of the best work along research lines was accomplished. Evidently after man had learned to raise himself from the ground by means of a power-driven machine, he was so busy playing with the new toy that he could not devote the painstaking care necessary for scientific research.

Now that the aeroplane has reached a relatively high state of development I believe that we should again revert to the scientific man. In other words, I believe that the future of the aeroplane hereafter rests largely with the scientist as compared with the man operating by rule of thumb. To the laboratory we must look for our greatest addition hereafter to the scientific knowledge of aeronautics.

The essential features of the modern aeroplane, whether it is a monoplane or a biplane, are as follows: main supporting planes, fuselage or body, landing chassis,

motive power, propeller or propellers, and means for horizontal and vertical steering, as well as for maintaining longitudinal and lateral stability.

There is no difficulty in steering an aeroplane to the right or to the left, nor is there any difficulty in maintaining its stability in a fore and aft direction. The longitudinal stability of the modern aeroplane is well nigh perfect. Five times over the city of Boston at a height of 3,000 feet I took my hands from my



A Complete Equipment. Cockpit of the author's 70 H. P. Gnome driven Blériot Monoplane.

longitudinal control. The machine did not pitch forward violently or have a tendency to settle backward, but assumed a natural gliding angle. The aeroplane of today, if properly designed, is longitudinally all that could be desired.

The problem that is awaiting solution and the problem on which the whole future of the aeroplane depends, is that of maintaining what is called lateral stability. In other words, keeping the machine in more or less of a horizontal plane.

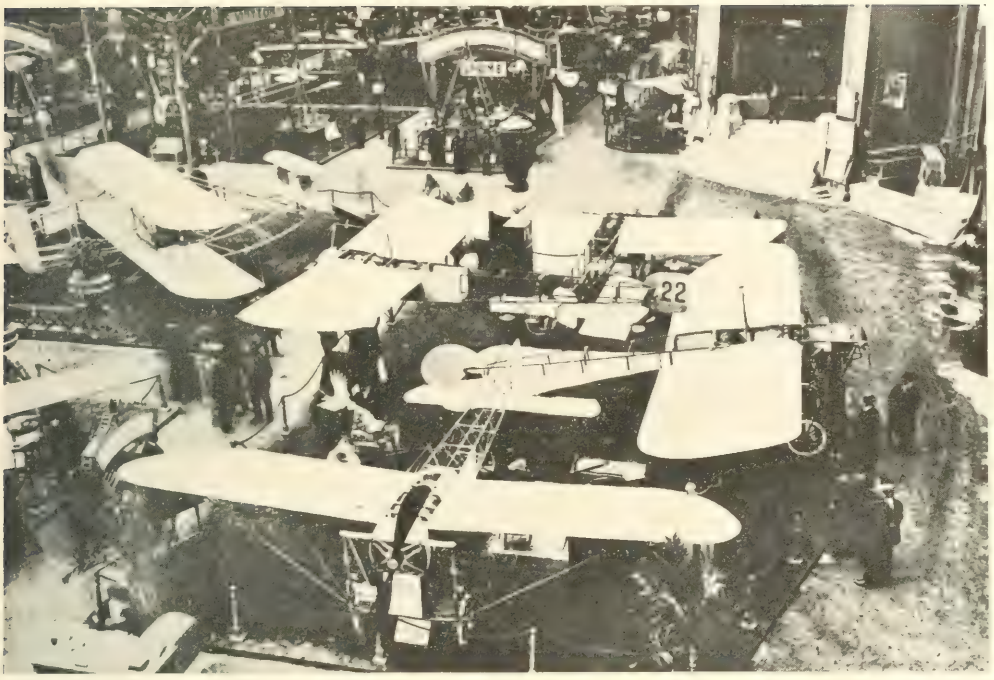
Any aviator will agree with me when I say that the operator at the control of a flying machine is in very much the same position as the tightrope walker. He is balancing at all times upon the invisible air currents just like the tightrope walker is balancing upon his narrow support. It is the continual strain of this lateral balancing which makes aeroplane flying today as difficult as it is. It is this continual fighting with the tendency of the machine to capsize, which makes the aviator a nervous wreck in a few months unless he is very careful. Some men stand this mental strain better than others; the ability to resist the action seems to be constitutional. It affects them all, however, to a greater or less extent.

For the benefit of those who may have some ideas on this subject of lateral stability, or who may wish to study it, I should like to say a few words more on the subject.

There are three methods of maintaining a flying machine in a normal position viewed from a lateral stability standpoint. First: the control of the machine by means of the aviator. Second: the control of the machine by means of automatic devices, such as a pendulum or a gyroscope. Third: building the aeroplane surfaces in such a manner that they are inherently stable.

The first method is the method employed at the present day in practically all modern aeroplanes. In this case the life of the aviator depends upon his ability to maintain his lateral stability.

The second method is one almost always striven for by the novice and the man who knows little about aeronautics. The aviator who has actually flown knows that he would rather risk his life to his own brain than to some automatic device. Assuming that a perfect automatic device could be obtained, there would come a time when it would cease to operate, and then death might result, or at least a serious accident.



Paris Aviation Exhibition in the Grand Palais -Financially more successful than any of the automobile shows held there

I believe that the future of the aeroplane will evolve a machine having *inherent* lateral stability, which is the third method of the three above mentioned, and until this time comes, the aeroplane will not be the universally used vehicle. I am sure it will be sooner or later.

Many people have asked me why birds are able to soar as they do without the expenditure of energy on their own part. This has ever been an interesting problem to the students of aerodynamic flight, and in spite of the fact that there is considerable mystery attached to the phenomenon among laymen, it is well understood among those versed in the art.

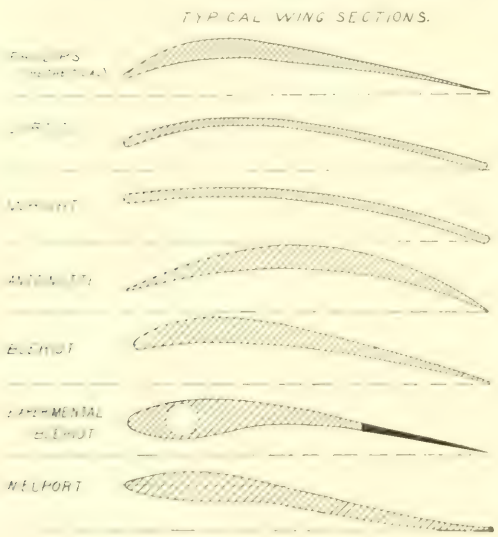
Broadly speaking there are two classes of birds; the flapping bird and the soaring bird. The wings of the former are short and thick, that is, they have a low aspect ratio, the aspect ratio being the ratio of the length to the breadth. Their wing area, too, is small per unit weight. Vigorous flapping is necessary for flight, and enormous energy is expended compared with that used by the soaring bird.

In the case of the soaring bird, of which the condor and turkey buzzard are the best examples, the wings are long and narrow, that is, their aspect ratio is high. The wing area is comparatively great when the weight is considered. Flapping is not only unnecessary, but is often absent for hours. Where, then, do these birds get their energy?

It is easy to understand that if a bird were to jump off a prominence such as a high hill or a church steeple, he could glide gradually to the ground. Now I think it will be equally evident that if after the bird had found himself launched in the air, he discovered that the air was rising rapidly, he could actually remain stationary with regard to the earth, although he would be falling with respect to the surrounding air which was sustaining him. This is what happens in most cases of flights by soaring birds.

Although there may be no appreciable wind at a given moment, if we could see the movement of the air, we would find that it was rising over some portions of the ground and descending in the other neighboring portions. In other words, the air may be warmer in certain places and rise, while being colder in others, it descends. The birds have a faculty of utilizing the rising currents of air, and often soar for hours in circles utilizing the upward trend of such air currents. Or perhaps they may use the upwardly deflected current from some hill or other prominence.

This, too, explains why sea gulls can



follow an ocean liner without flapping. The air is rising from the stern of the boat because it is heated, and the gulls soar in this rising current of hot air. It is interesting to note in this connection, that the energy of the coal burned under the furnaces of the boat supplies not only the necessary energy to propel the giant ocean greyhound through the water, but furnishes the power which enables the little winged followers to glide forward through the air without the effort of propulsion. The gulls, when soaring, are literally abstracting the energy they require from the air itself.

There are cases where a bird can soar in horizontally moving currents. For instance, suppose the bird is gliding forward at a certain speed against the wind, but in a slightly downward direction. Now assume that the wind velocity is increased. It is evident that the bird will be able to rise, abstracting some of the energy from the pulsation of the air sustaining him. But this is not the usual means by which birds soar—it is only utilized under certain conditions.

I have often been asked the question whether man will ever be able to soar as the birds do. It may be that in the distant future we may develop in us a sense which will enable us to "feel" the invisible currents of rising air, but I very much doubt it. Neither do I see as it would be of great benefit, as unquestionably all birds have to flap if they wish to go definitely from one point to another, and the conditions are not such that they can soar. I do believe, however, that the time will come when five or, at the most, ten-horsepower, will be all that is required to carry a man through the air in a flying machine. Under such circumstances it would make little difference whether soaring flight were possible or not, that is, soaring flight without an engine.

A question which undoubtedly has been asked me more than any other is, "How does it feel to go up in an aeroplane?" People seem to think that every time I get into the machine and go off the ground I am terribly frightened, and only manage to control myself with the greatest effort. And they are under the impression that if they themselves went up, they would probably be in a panic of fear.

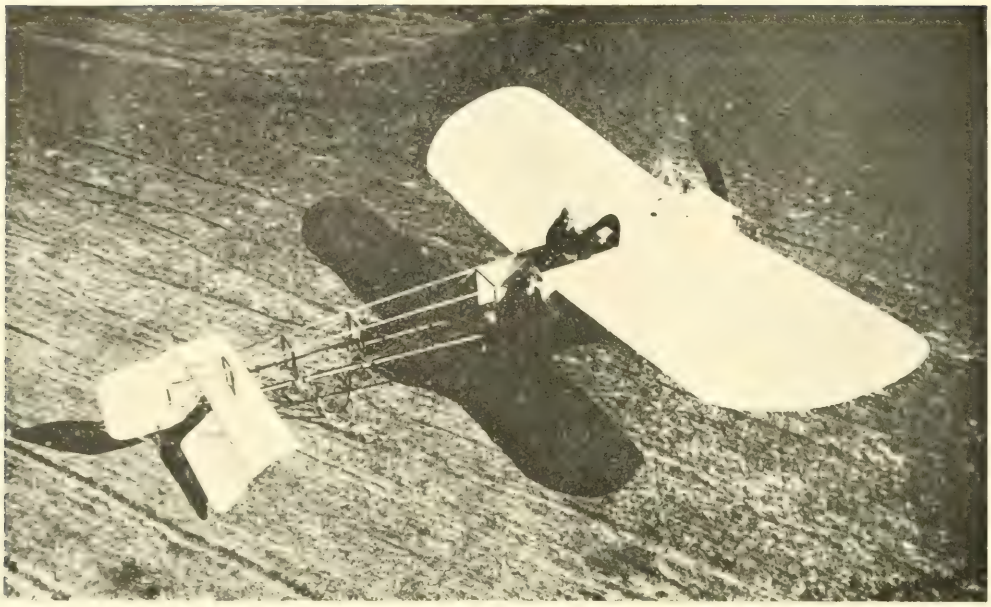
Nothing is further from the case. I have seen a great many ladies go up as passengers—timid society women who would scream with terror at the sight of a mouse. At first, of course, while they were taking their seat in the aeroplane and preparing for the flight, they would be nervous. I presume they felt very much like a criminal about to be electrocuted. The dread of anticipation, however, is the greatest unpleasantness of the whole proceeding. A passenger is no sooner in the air than a false feeling of safety is experienced. I say it is false,

The Students' "Dummy" at the Antoinette School in France. This permits the student to practice before actually attempting flight

because aeroplaning of the present day is distinctly a dangerous pastime. As one looks out, however, over the immense planes of the machine, and hears the positive and reassuring roar of the motor, it seems impossible to grasp that this man-made bird could fall.

In my own case I made my first flight with Maurice Farman at Buc in France. The day was calm, and after a momentary uneasiness, I settled down to really enjoy my first flight. Instead of the aeroplane leaving the ground, it seemed to me that the ground was leaving the aeroplane, and that we were suspended in the air, as if supported by a balloon instead of by the reaction of the air on the wings of the machine. As we climbed higher the earth appeared to be falling further and further away from me, and when we had reached a height of 500 feet, all nervousness had disappeared. So much so that I was talking, in rather a loud voice to be sure, to my pilot. What was my surprise when Mr. Farman indicated that I was to take the controls of the machine. I did so with some trepidation, but managed without difficulty to steer the aeroplane and maintain its stability. Mr. Farman would not have taken these chances had he not known that I was thoroughly acquainted with the theory of the subject. He realized how easy it was to fly on a calm day in a big biplane, and so had no hesitance in handing me the controls of the machine as soon as we got far enough away from the ground to prevent a sudden swoop causing an accident. Of course he was ready at a moment's notice to check me, if I made a false move, but this was not necessary. Indeed, I was surprised at the ease with which an aeroplane could be manipulated.

Don't gain from this that flying is always so easy. In the first place I was in a big biplane, and in the second place the air was comparatively calm. Flying



The author's 70 H. P. Gnome Driven Blériot Monoplane

in a wind is a different proposition, as I have learned since. Flying an aeroplane on a calm day, and flying one in a high wind, is the difference between rowing in a flat-bottomed skow on a mill pond, and handling a sailing canoe in a gusty gale.

I have the honor of having made the first aeroplane flight over the city of Boston. I started from the Waltham aerodrome, and after I had reached the height of three or four thousand feet, I headed in the direction of Boston, and was soon sailing over the Back Bay district. Far below me I could see the little ant-like people as they ran backwards and forwards through the streets. The bridges over the Charles River were black with mites of humanity. The river itself was strewn with pleasure craft filled with those who had come to see me fly, since it had been announced the day before in the newspapers that I would make the attempt.

I was told to steer for the State House dome, and would have no difficulty in finding it because it was gilded. I looked around and couldn't see anything that looked like gold, although I flatter myself that I can detect the presence of the yellow metal about as far as the next fellow. What I did see, however, was a red spot, and this afterwards proved to be the dome of the State House. They were just putting on a new coat of goldleaf, and had painted the dome red preparatory to the finishing process.

It is very difficult, indeed, to describe the appearance of a large city like Boston when one is flying half a mile to a mile above it. Of course, you get an absolutely plain view. You see far below you a busy world just as when you are standing above an ant hill you see the little insects rushing to and fro about their labors. Far out in the harbor was a big steamer just coming into port, and I could tell by the steam coming from its whistle that they were signaling to me, although I could not hear them on account of the roar of my engine, and because I sit above my planes, and these act like sound reflectors, and throw the sound downward.

After sailing out over the harbor, I pointed my machine towards the Waltham aerodrome, and following the Charles River it was only a few minutes

The author rounding the State House Dome—First aeroplane flight over Boston

before I was back in Waltham again. To make the trip that I did, in an automobile, would have taken an hour and a half, and it took me just twenty-one minutes. When you appreciate the fact that I was making this remarkable trip in a mechanical device which was literally in its infancy, can you have any doubt whatever as to the future of the modern aeroplane? It is simplicity itself, is inexpensive to build, and is the speediest means of locomotion extant. As I said before, there is only one problem that stands before the universal use of the aeroplane, and that is the one of maintaining lateral stability. As soon as this problem is solved, the aeroplane will take its position among other means of transportation as a commercial proposition.

Speaking of the future of the aeroplane, I should like to say a few words. Will aeroplanes ever replace ocean liners and railroad trains? How long before the aeroplane will be made which will carry a hundred people with the comfort and convenience of the Atlantic liner?

I may be mistaken in my idea of the future of the heavier-than-air flying machine, but I do not think that it will ever be a vehicle for carrying a very large number of people. The automobile is essentially a means of locomotion for only a few people at a time, and I believe that the aeroplane will in this way prove similar.

It would be impossible for any of us, however great an imagination we might have, to form a very concrete idea of the aeroplane fifty years from now, but I believe we are safe in speculating as to what its position will be within the next five years.

Of course, the first use will come in war and in carrying light merchandise, such as registered mail, with the greatest speed and over the roughest countries.

As soon as the dangers of the aeroplane have been largely eliminated, that is, as soon as aeroplaning is made as safe as automobiling, I believe one of the first effects will be to extend the suburban area. In other words, a man will own

A Smash at Blériot's School, Pau, France. It was here the author learned to fly

his aeroplane, and either have his private hangar and aerodrome, or will house his machine in the public hangar and start from the public aerodrome. He will reside say fifty or a hundred miles from the large city in which his place of business will be located. In the morning his aero-chauffeur will take him with the greatest possible speed and with the least personal inconvenience to the outskirts of the big city. Here a descent will be made upon one of several public aerodromes which will be located on the outskirts of the great city. These aerodromes will be the terminals of the electric railroads, taxicabs, and other means of land locomotion.

Our business man of the future will now leave his aeroplane in charge of his aero-chauffeur, and go to his business either in his automobile or in one of the more prosaic lands methods. In the meantime his aero-chauffeur has taken the aeroplane into one of the hangars surrounding the big public aerodrome which hangar our business man may possibly rent by the month. A careful examination of the engine and the machine itself will be made preparatory to the trip home in the evening.

I do not believe that flying over large cities will be permitted as soon as aeroplanes become more common. However safe the aeroplane may be, there are times when it will fall suddenly to the earth, and it is not right to subject the residents of a populated district to such a danger. Even in flying back and forth from the aerodrome, I think that the route will be over comparatively sparsely settled areas with perhaps emergency aerodromes every twenty miles or so.

I have always been an advocate of high flying. It is never the fall which hurts, but the sudden stop. Fly at the height of a mile and with a gliding angle of one in six, which is perfectly practical at the present time, you have a circle

THE SOCIETY OF ARTS OF THE MASSACHUSETTS INSTITUTE OF TECHNOLOGY

The Society of Arts was established as a department of the Institute by President Rogers in 1861. It is especially devoted to the general dissemination of scientific knowledge, and it aims to awaken and maintain an interest in the recent advances and practical application of the sciences.

Any person interested in the aims of the Society is eligible to membership.

The annual dues are $3.

RICHARD C. MACLAURIN, President of the Institute.
ISAAC W. LITCHFIELD, Secretary of the Society of Arts.

EXECUTIVE COMMITTEE

ELIHU THOMSON
JAMES P. MUNROE
THE PRESIDENT
THEODORE N. VAIL
CARROLL W. DOTEN
FREDERIC H. FAY

THE SECRETARY

BOARD OF PUBLICATION

D. F. COMSTOCK
SELSKAR M. GUNN
ELLWOOD B. SPEAR
LEWIS E. MOORE

I. W. LITCHFIELD, Editor

SCIENCE CONSPECTUS is published December, January, February, March and April.

having a diameter of twelve miles upon which to land. If now, the emergency aerodromes are sufficiently numerous, there need be no danger whatever of making a landing upon other than a proper field. And I look to the great improvement of the gliding angle of the aeroplane. There is no reason why we should not obtain a gliding angle of one in twenty or better.

As far as the construction of the machine is concerned, I don't think there is a great future for the present aeroplane composed of wood, wire, and canvas. Sooner or later the all-steel aeroplane is going to be the only practical construction. The reason it is not at the present time is because weight is of such momentous importance, and wood is lighter than steel in proportion to its strength. With a further improvement in the lightweight gasoline engine, however, this matter of weight will not be of such importance, and then will come the all-steel aeroplane. And as I have already stated, I believe that ten horsepower will be all that is required to carry one man through the air on a heavier-than-air flying machine. Of course, a higher powered motor will be used, but only to obtain speed. It will not be necessary for sustention.

Believing as firmly as I do in the future of the aeroplane, I cannot do better than to conclude my remarks by emphasizing the fact that there is a great future for the aeronautic engineer. Most of the engineering professions are overcrowded at the present time. Here is a new science waiting for competent men to grapple with the problems it holds forth. Personally I am of the opinion that the young college graduate of today, and the graduate of the technical school, could do nothing better than adopt as his life's work the profession of aeronautical engineer. It's an old saying that "the early bird catches the worm," and I believe that the remuneration will be very great during the formative period of the new science of aerial locomotion. The time has arrived in the development of the heavier-than-air flying machine when the services of the expert engineer are required in order to carry the development to its logical conclusion. You young men who are casting about in an effort to decide which profession you will adopt, will do well if you give weighty consideration to the new profession of aeronautical engineering; it offers unlimited opportunities to the trained man with initiative. Incidentally the work is wonderfully fascinating.

THE RADIATION OF THE SUN

SOLAR RESEARCHES THAT MAY GIVE US A BETTER UNDERSTANDING OF THE FLUCTUATIONS OF TEMPERATURE, CLOUDINESS AND RAINFALL

BY C. G. ABBOT*

THE sun presents many interesting aspects. Although controller of the solar system, an object rich with beautiful and curious features, the nearest of the fixed stars, and typical of a large class among them, the sun also has a still greater claim on human interest as the fountain of heat, light and life upon the earth. It is this latter aspect which we shall consider mainly, still further confining our attention almost wholly to work done under the auspices of the Smithsonian Institution.

When James Smithson died in Genoa in 1829 he left his estate, subject to certain conditions, "to the United States of America, to found at Washington, under the name of the Smithsonian Institution, an Establishment for the increase & diffusion of knowledge among men." On May 9, 1838, by decree of the English Court of Chancery, the Smithson bequest, amounting to about $500,000 was adjudged to the United States. By the act of establishment in 1846, the control of the Smithsonian Institution is vested by Congress in a Board of Regents comprising the vice-president and the chief justice of the United States, three senators, three representatives and six private citizens. The Board perpetuates itself by election. In the years that have elapsed the Smithsonian private funds have increased by gifts and economy to nearly $1,000,000. For many years the institution has administered the annual congressional appropriations for the support of the National Museum, National Zoölogical Park, Bureau of American Ethnology, Astrophysical Observatory, Bureau of International Exchanges, and International Catalogue of Scientific Literature. The immediate administration is in the hands of the secretary of the Board of Regents, at present Dr. C. D. Walcott, the fourth of the secretaries.

Dr. S. P. Langley, the third secretary, a distinguished American astronomer, founded in 1890 the Astrophysical Observatory of the Smithsonian Institution, and was its director until his death in 1906. His own principal investigations, and those of the Astrophysical Observatory begun under his direction and still continued, have lain in the field of measuring the quantity and quality of the sun's radiation, the effect of the earth's atmosphere thereon, and the dependence of terrestrial temperatures and plant life on solar radiation. This is a utilitarian branch of astronomy, whose applications to terrestrial concerns may be expected to increase in future years and result in the promotion of the arts of meteorology and agriculture. But the interest of such studies for the promotion of pure knowledge is also very high. Let us imagine that the Greek philosophers, the Arabians, and the astronomers of Galileo's time, had all possessed the means to measure accurately the quantity and quality of solar radiation. How interesting it would be now to compare their measurements with our own, and determine thereby what, if any, appreciable changes have occurred in 2500 years in that energy which supports heat and life upon the earth! The astronomer of the future will have, we hope, trustworthy measurements of our own time to compare with his own. Referring to another branch of the measurements which I am to bring before you, our knowledge of the approximate temperatures prevailing in the sun, and our conclusions as to the sun's nature

Presented [illegible] by the Secretary of the Smithsonian Institution. Illustrations in part from "The Sun" [illegible] D. Appleton & Company.

Smithsonian Institution, Washington

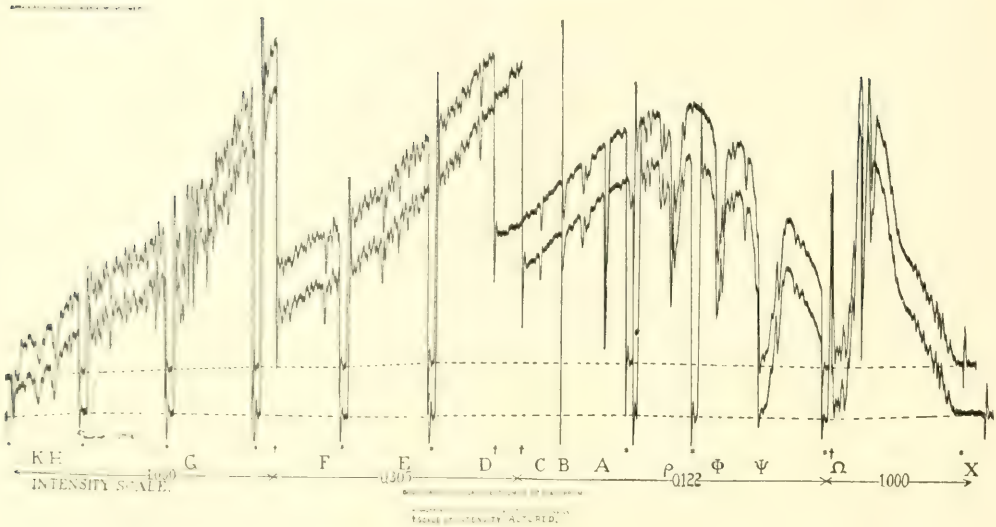


Plate 3, Fig. 1

rest on such work as is being done at the Smithsonian Astrophysical Observatory.

By the term solar radiation, I propose to your minds not only the solar rays which affect our eyes as light, but the extensions of the spectrum beyond the violet and beyond the red, where the eye is not sensitive. All these rays, whether visible or not, may be absorbed by blackened surfaces and will thus produce their just and proportional effects as heat. For the measurement of solar radiation, Langley, about 1880, invented the delicate electrical thermometer shown in Plate 2 which he called the bolometer; Fig. 8 of Plate 2 shows its most important part. This is a pair of tapes of platinum, each about 1 centimeter long, 0.01 centimeter broad, and 0.002 centimeter thick. These tapes are blackened with camphor smoke, or by a deposit of platinum black. One is exposed in the path of the rays to be measured, and the other is hidden. Hence one tape is warmed with respect to the other. Thereby a minute electrical current is caused to flow through the delicate galvanometer connected with the Wheatstone's bridge of which the tapes form two arms. In this way a change of temperature, which may be as small as one millionth degree Centigrade, may be detected in ordinary practise. By special devices the sensitiveness may be increased beyond this one hundred fold. But though so sensitive the bolometer is far behind the eye in its capacity to detect faint yellow light. It is used in preference to the eye because

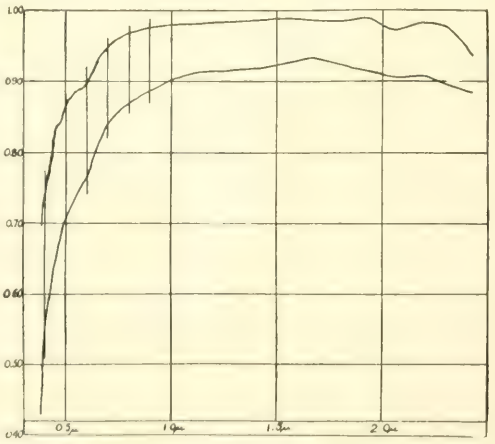


Plate 3, Fig. 2. Atmospheric transmission Mt. Wilson and Mt. Washington

it can detect and correctly measure the relative intensities of rays of all wavelengths whether visible or not.

The indications of the bolometer may be automatically observed by photography, and thereby the solar spectrum

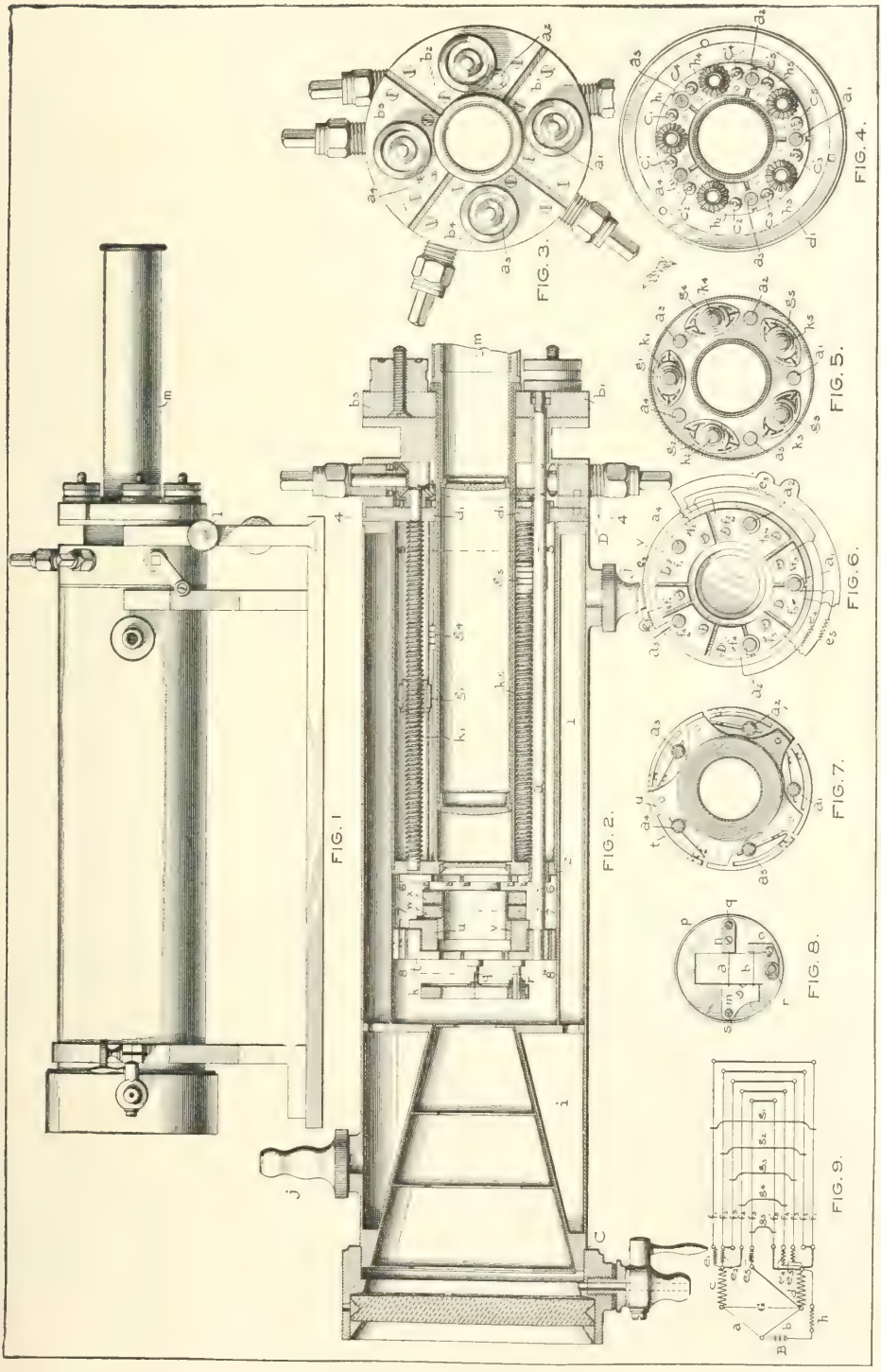


Plate 2, Fig. 8. Bolometer and its adjustments

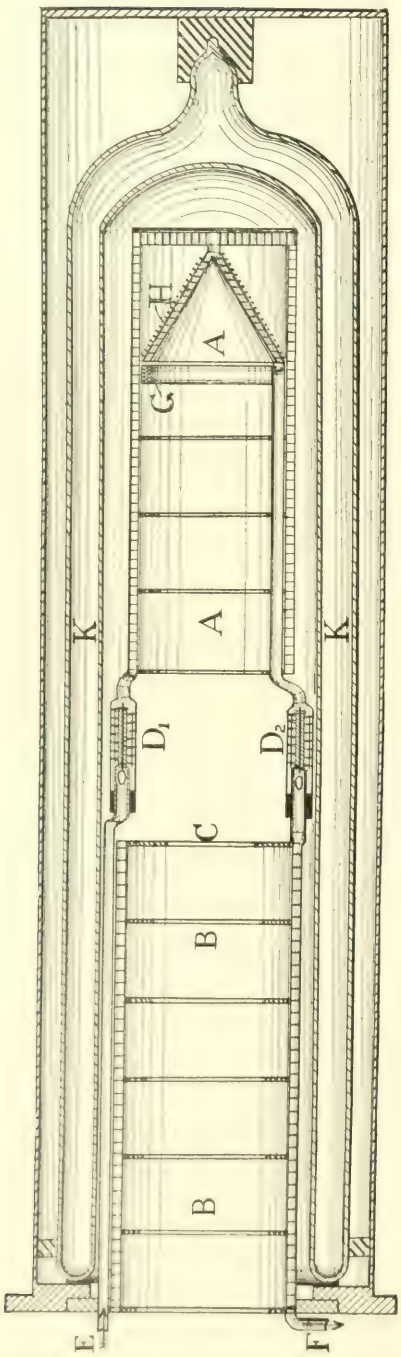


Plate 4, Fig. 1. Abbot Standard Pyrheliometer. Radiation falls on cone at A; Resistance thermometers at D_1 and D_2; Water flows in at E, out at F; G and H, coils for electrically known amounts of heat

may be exhibited, as in Plate 3, Fig. 1, as a sinuous line whose elevation above the base line of zero radiation gives the relative intensity of the different colored or invisible rays. The two curves shown are taken independently about an hour apart, for the purpose of studying the increase of intensity of the sun's rays of different wave-lengths as their path in air diminishes in length in consequence of the approach of the sun to the meridian. From such studies the results shown in Plate 3, Fig. 2, are found. The upper curve represents the percentage transmission of a vertical column of air above Mount Wilson (elevation 1750 meters) while the lower curve shows the less transmission for vertical rays at Washington (30 meters). The wave-lengths are indicated as abscissæ. From this we see how much more loss the violet rays of wave-length 0.40μ suffer than do the red rays of wave-length 0.70μ in traversing the air.

In order to determine the quantity of the solar radiation, we must fix our conditions independent of the variable losses in the atmosphere. We attempt, therefore, to make the observations in such a manner as to permit a correct estimate of the atmospheric losses, so that the result can be expressed as if the measurements were made in free space beyond the atmosphere. But of course our actual work must be done at the earth's surface. We express solar radiation in heat units called calories. As the bolometer is not of itself capable of giving true calories we have devised an instrument shown in Plate 4, Fig. 1, a standard pyrheliometer, so called. A is a chamber of nearly the dimensions of a large test tube, whose walls are hollow and adapted for the circulation of a stream of water. The stream enters at E, bathes the walls and rear of the chamber and the cone-shaped receiver of rays H and passes out at F carrying the heat developed by solar rays which enter the chamber by the measured orifice C. At D, and D_1 and D_2 are platinum coils adapted to measure the rise of temperature of the water due to solar heating. Knowing the weight of water per minute, the rise of temperature and

Plate 5, Fig. 1. Mt. Wilson Solar Observatory

the area of the opening C for solar rays, their intensity is determined. As a check, heat may be produced electrically in the chamber, and the proof of the accuracy of the instrument consists in finding the known quantity of electrically introduced heat correctly measured. Another simpler instrument for every day use is the Silver Disk Pyrheliometer shown in Plate 4, Fig. 2, which may be standardized against the water-flow instrument and in which the measurement is made by reading a thermometer at stated intervals.

In measuring the intensity of solar radiation as it would be outside the earth's atmosphere at mean solar distance (generally called the Solar Constant of Radiation) it is important to select a station where variability of atmospheric conditions is slight, and where the quantity of air traversed by the solar rays is small. Owing to smoke and clouds, Washington is a poor locality for the purpose, and so in 1905 an expedition in my charge was sent by invitation of Director Hale of the Mount Wilson Solar Observatory, to take station on Mount Wilson. Plate 5, Fig. 1, shows some of the gigantic apparatus erected by Director Hale at that fine site. With this remarkable outfit the work done by the Mount Wilson Solar Observatory Staff has been wonderfully productive. The Smithsonian Observatory on Mount Wilson, a little affair comparatively, is shown in Plate 5, Fig. 2. It was built in 1908 on a small plot of ground leased from the Solar Observatory. A cottage has since been built close by for observers' quarters.

In order to test more thoroughly whether we can indeed truly estimate the losses of solar rays in our atmosphere, work was done in 1909 and 1910 under my charge at Mount Whitney (4420 meters) the highest mountain in the United States. To further the work of this and other scientific expeditions, the Institution erected on Mount Whitney

Plate 5, Fig. 2. Smithsonian Observatory, Mt. Wilson

in 1909 the stone and steel shelter shown in Plate 6, Fig. 1. My apparatus is shown in Fig. 2. With Mr. Marsh of Lone Pine, I remained two weeks on the summit in 1909 and again in 1910, and made measurements of the solar constant of radiation there, while my colleagues made similar measurements at Mount Wilson. The following table shows the results:

	Sept. 3, 1909.	Aug. 12, 1910.	Aug. 13, 1910.	Aug. 14, 1910.
Solar constant:				
[illegible]	1.943	1.943	1.924	1.904
[illegible]	1.980	1.979	1.965	1.956

Taking the mean of the differences between the results obtained simultaneously at the two stations, it appears that the results obtained on Mount Whitney average 1.4 per cent. higher than those obtained on Mount Wilson. But considering that the optical apparatus used on Mount Wilson comprised a silvered glass mirror coelostat, an ultra-violet crown glass prism, and two silvered glass mirrors, while that on Mount Whitney comprised only a quartz prism and two magnalium mirrors, and, furthermore, that the pyrheliometers employed at the two stations were read at very different temperatures, it is probable that the slight difference found between the results may be due wholly to experimental differences and implies no discrepancy due to the difference of altitude between the two stations.

This conclusion seems worth emphasizing. We have now made simultaneously solar-constant determinations at sea level (Washington), at over a mile altitude (Mount Wilson), and again at Mount Wilson, and at nearly three miles

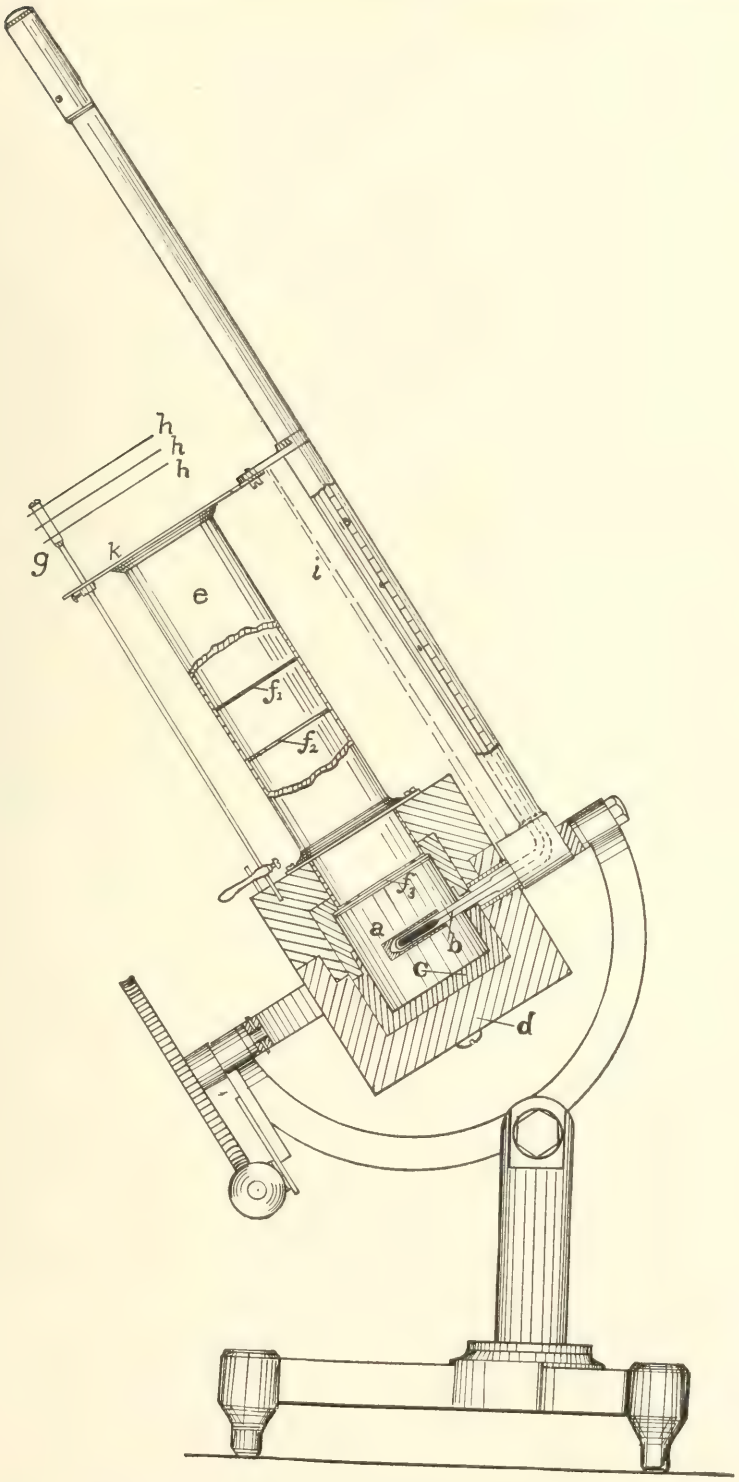


Plate 4, Fig. 2. The Abbot Silver Disk Pyrheliometer

Plate 6, Fig. 1. Pack train at Smithsonian Shelter, Mt. Wilson

altitude (Mount Whitney). Although both the quantity and the quality of the solar radiation found at these stations differ very much, neither the "solar constant" nor the distribution of the solar energy in the spectrum outside the atmosphere, as fixed by the wholly independent measurements at these three stations, differs more than would be expected in view of the unavoidable small errors of observation. We seem justified in concluding that we do, in fact, eliminate the effects of atmospheric losses and actually determine the true quantity and quality of the sun's radiation outside the atmosphere as we might do if we could observe in free space with no atmosphere at all to hinder.

Expeditions to Mount Wilson have now been made in 1905, 1906, 1908, 1909, 1910 and 1911 continuing from May until November. In the earlier years the observations were not made daily, but in 1908, 1909, 1910, and 1911 daily

	Washington.	Mount Wilson.					Mount Whitney.	
	1902–1907	1905	1906	1908	1909	1910	1909	1910
[illegible] observed	44	59	62	113	95	*28	1	3
Mean value	1.960	1.925	1.921	1.929	1.896	1.914	1.959	1.956

[illegible] observations not yet ready. General mean, 1.922 calories (15° C.) per square centimeter per minute. Number of determinations, 446.

Plate 6, Fig. 2. Mr. Abbot's Apparatus on Mt. Whitney

determinations of the solar constant were made when possible. I give below a summary of this work up to the middle of 1910, and with it also the results obtained at Washington and at Mount Whitney.

We draw the conclusion that, for the epoch 1902 to 1910, an object in outer space, at the earth's mean solar distance, would have received radiation on surfaces at right angles to the solar beam at the mean rate of 1.93 calories per square centimeter per minute. What a prize would be given to one who could bring us similar measurements dating, let us say, from the time of Archimedes!

Before considering the possible variability of the sun we may pause to note some of the by-products of the solar constant measurements. Referring again to Plate 3, Fig. 1, we see before us the distribution of energy in the sun's spectrum observed at a particular time on Mount Wilson with certain apparatus. Knowing from other observations of the same day the losses suffered by the rays in the air, and being able to measure also the losses suffered in their passage of the optical apparatus, it is possible to compute the form which the solar energy spectrum would assume if observed outside our atmosphere, with perfectly transparent apparatus capable of forming a normal spectrum. Such a curve is that marked "All" in Plate 7, Fig. 1. It is marked "All" because it represents the mixture of rays from all parts of the sun's disk, just as we ordinarily get them. Plate 7, Fig. 2, shows a number of curves of distribution of rays along a diameter of the sun. From these we see that the sun's disk is not of equal brightness from edge through center to edge, and that the contrast of brightness is far greater the shorter the wave-length considered. In other words, the sun's edge is much

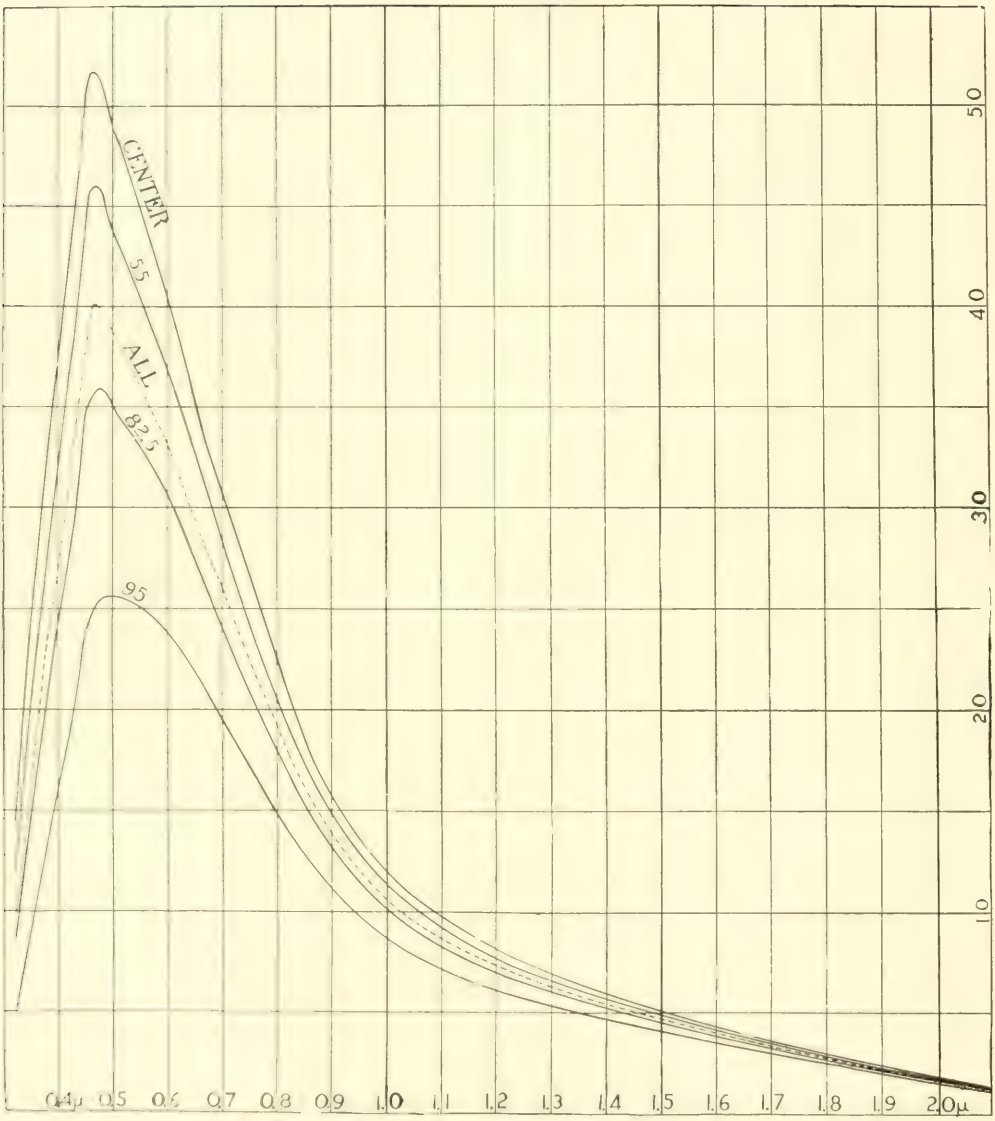


Plate 7, Fig. 1. Energy Spectra over sun's disk

dimmer compared to its center for the ordinary photographic plate than for the eye because the plate is most sensitive for violet and ultra-violet rays, while the eye is most sensitive in the yellow. Returning again to Plate 7, Fig. 1, the other curves show the relative intensities of solar energy of all wave-lengths taken from points distant zero 55, 82.5 and 95 per cent. respectively, from the center of the sun's disk. The intensities, as you see, diminish as we go out towards the sun's edge in all wave-lengths, but most rapidly for the shorter wave-length rays. Hence not only does the height of the energy curve alter, but its form changes, so that the place of maximum intensity shifts towards the red as we approach the sun's edge. This is a peculiarity of spectra of heated bodies at successively

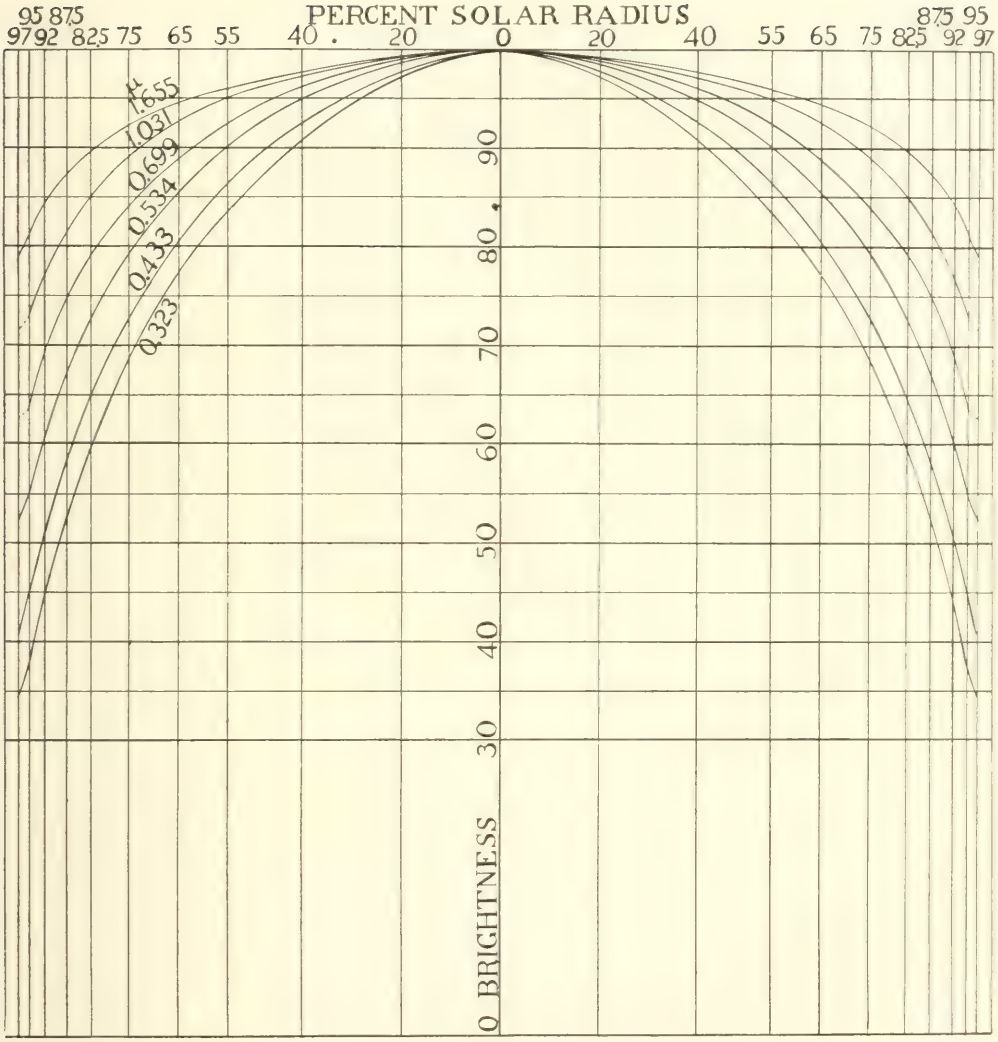


Plate 7, Fig. 2. Radiation along diameter of sun's disk

lower temperatures. It is quite reasonable to conclude that the light we see near the edge of the sun comes from regions of lower temperature than that which we get from the center of the disk. This is probably because our view is cut off before it penetrates very deeply, at the edge, because we are there looking very obliquely. Thus we see only superficial layers at the edge, and much deeper and hotter ones at the center. But all these temperatures are very much higher than any we know on the earth. The electric arc, for instance, is said to be at a temperature of about 3800° absolute Centigrade. From the form of the solar energy curve, the value of the solar constant, and other data, we estimate that the solar temperatures range from about 6000° absolute Centigrade upwards.

As the temperature of the earth depends almost directly on the quantity of solar radiation we are immediately interested to inquire if the sun, like so many others of the stars, is variable, and if so what corresponding variations

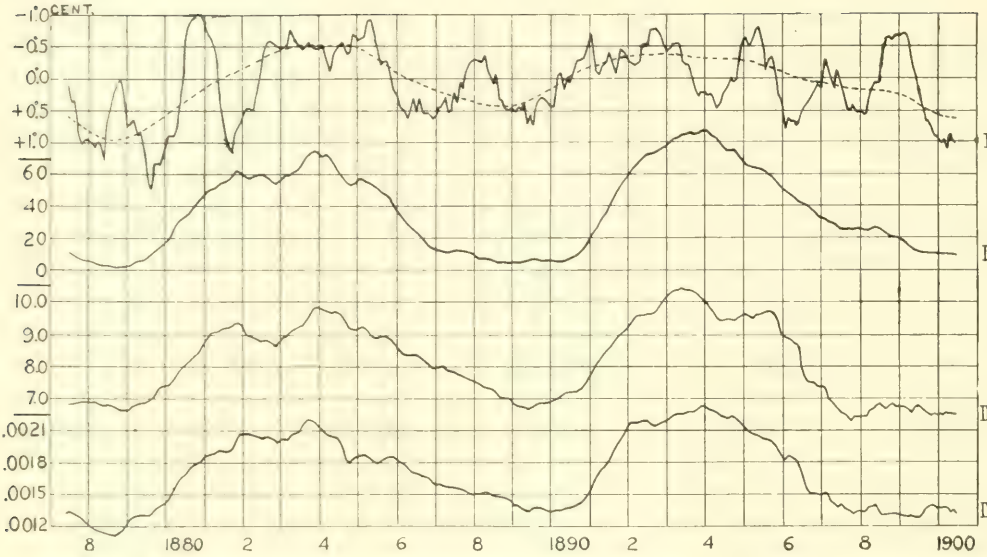


Plate 8, Fig. 1. Sun spots and terrestrial temperatures and magnetism. I. Departures of maximum temperature for United States. II. Sun spot members (Wolfer). III. Decimal range magnetic declination (Ellis; Chree). IV. Decimal range horizontal magnetic force (Ellis; Chree)

are produced in the temperature, cloudiness and rainfall of the earth. It has been known for over half a century that the sun has a slight variability of an average period of about 11 years, corresponding with the fluctuations of the number of sun spots, the changes in form of the solar, corona, and other solar phenomena, and inducing changes in the prevalence of the aurora borealis, the magnetic force and declination, and other terrestrial phenomena. Plate 8, Fig. 1, shows in its first curve the variation from normal of the temperature of the United States, second the variation of sun-spot numbers, third and fourth the fluctuations in terrestrial magnetic elements for the period 1878 to 1900. It would be of great interest if we had accurate solar constant measurements to compare with these changes for a long period of time. Unfortunately we have none such earlier than 1903 and only scattering measurements until 1905.

In Plate 8, Fig. 2, the results of solar constant measurements on Mount Wilson 1905 to 1909 are given. On their face they indicate a fluctuation of the intensity of solar radiation. The fluctuation extends over a total range of nearly 10 per cent. In the later years the measurements were made almost daily, and seem to bring out with certainty that the changes are not haphazard in their character. Successive days of observation indicate a gradual march of the solar constant values from a high to a low and back. Had the variations been due merely to accidental errors we should not have expected this regularity. Hence we conclude that the changes observed are either really solar or are due to some obscure source of error in estimating the losses in our atmosphere. The latter supposition is not very reasonable because as already shown we get practically identical solar constant values whether we observe at sea-level (Washington), 1 mile (Mount Wilson), or 3 miles elevation (Mount Whitney). Hence it seems most probable that we have found a real variation of the sun, irregular in amount and period, but of an average period of 7 to 10 days, and an average magnitude of 3 to 5 per cent. This would be "important if true"!

To test the supposed variability of the sun conclusively an expedition under my charge occupied the station Bassour in Algeria from July to November 1911,

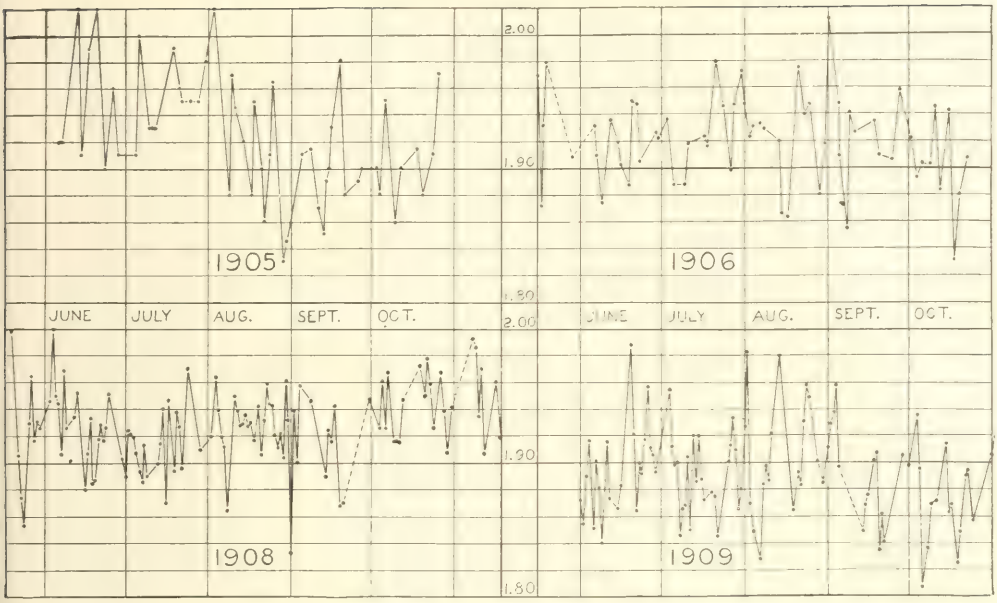


Plate 8, Fig. 2. Variations of the sun

and made there spectrobolometric determinations of the solar constant of radiation on every fair day while my colleague Mr. Aldrich made similar studies on Mount Wilson in California, distant about one third the earth's circumference. The observations are now being reduced, and we expect to know very soon whether or not the sun is really a variable star of short period. If it proves to be so, I venture to think that the result will be regarded as of so much interest that observatories in various parts of the world will take up the work of daily measurements of the solar constant of radiation. If the sun varies in this way we may, I think, reasonably hope that the knowledge of its fluctuations will enable meteorologists to understand better the fluctuations of temperature, cloudiness and rainfall.

THE USE OF OZONE IN BREWING

Ozone has now been brought forward as an aid to the production of better beer. Trouble with the fermentation not infrequently arises from an interference with the normal growth and activity of the yeast plant by the multiplication of certain bacteria. The result may be turbidity and lack of keeping quality in the final product. Experiments now show that yeast can withstand administrations of ozone which are fatal to the bacteria, and that the yeast can absorb and store the ozone to a considerable degree, giving it up only gradually. The application is obvious:—the purification of yeast by ozone and the use of such yeast in the fermentation. The results are represented as satisfactory, a beer being produced of normal taste and clarity and with much greater keeping power. F. S., JR.

MEMORY OR REFLEX ACTION?

M. Oxner finds that when a red cylinder containing food, and an empty green cylinder were placed in an aquarium a fish very quickly learned to enter the red cylinder each time it was immersed and avoided the green one. He further found that the fish would enter the baited red cylinder when the factor of hunger was eliminated, thus indicating habit or reflex action.

ANTICIPATING BUSINESS CONDITIONS

THE STUDY OF BUSINESS STATISTICS THAT HAVE BEEN GATHERED FROM WORLD-WIDE SOURCES WILL HELP THE MERCHANT TO DISCOUNT THE FUTURE

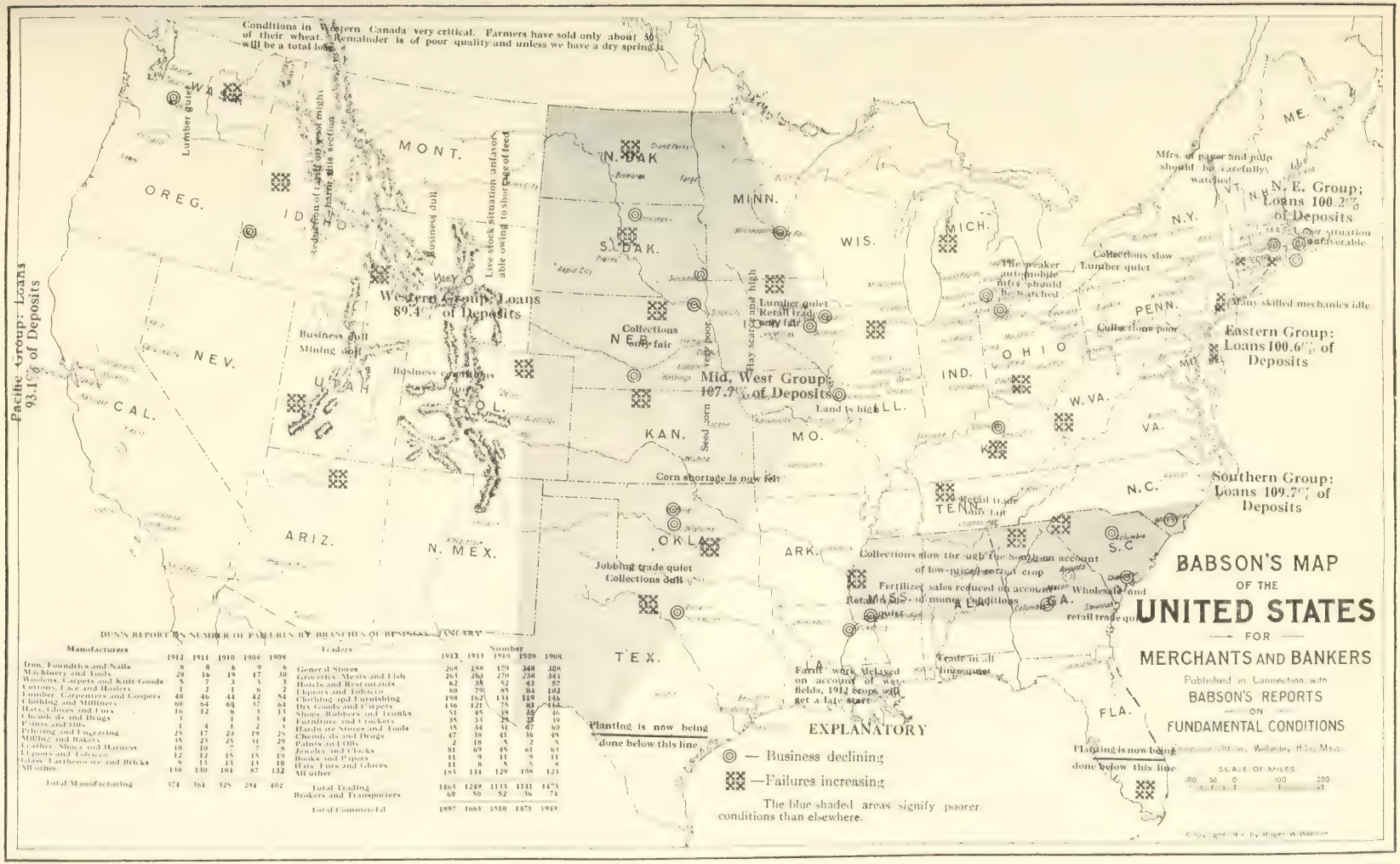
BY ROGER BABSON

WHEN a man is ill and goes to his physician, he really is not very much interested in the diagnosis of his existing condition. The question he asks is, "How soon am I going to get well?" What he is really wishing to know is how the present condition is going to affect his future health or happiness. The merchant in business, asking for the statement of some customer desiring credit, really does not ask for it for its own sake, but for the purpose of determining how the customer is drifting. He is vitally interested in the tendency towards better or worse of that customer. The same principle is a ruling one through all departments of life. The interest seems to be in the present, the facts demanded are of the present, but the true position in studying the facts of today is that their bearing may be established on the events of tomorrow. There is business interest in anticipating what effect these facts will have on the future prices of commodities.

The first requisite is a knowledge of conditions in all sections of the country

Now, the art of forecasting business conditions is really no different than the forecasts of the attorneys, or the physicians, or the credit men. The work really consists of two essential steps; an accurate knowledge of conditions in all sections of the country, indeed of the world and the study of these conditions as the weather bureau studies the movements of storms and areas of different barometric pressure. There is a tendency for the Boston merchant, especially he who sells only to Boston people or people in New England to think that the money he receives comes from Boston or vicinity. This is an error. Although the customers may be Boston people, nevertheless only a small portion of the money which they bring in comes directly from Boston sources. Much of it is from the cotton fields of the South, the cattle ranches of the Southwest, the mining camps of Montana, Utah and Arizona, the wheat fields and corn fields of our great Western country, the fruit orchards of the Pacific Coast, and the steel centers of Pittsburg, Bethlehem and Gary. Therefore, the future of even local Boston business depends not so much on conditions in Boston as upon the conditions in the South, the West, the Northwest and the Eastern Central States.

Therefore, to aid the wise merchant and manufacturer in anticipating business conditions, we first prepare for him a map of the country showing conditions in all sections. (Chart I). In fact, two maps of the United States are prepared and issued by us every two weeks, both of which are usually mailed to the president or general manager, personally, of the corporation which employs us. One of these is known as the "Optimistic Map," showing where business is best, where failures are fewest, where the crops are the most prosperous and where the various other conditions are such as to attract trade. If a corporation or firm does other than a local business, the president may hand this map to his sales-manager and advertising man so that the routing of the salesmen, the distributing of the advertising and all other work connected with the extending of sales may be centered on that part of the country where the greatest opportunity exists. In other words, such a map serves primarily to give the head of the business a comprehensive view of condi-



DUN'S REPORT BY NUMBER OF FAILURES BY BRANCHES OF BUSINESS—JANUARY

Manufacturers	1912	1911	1910	1909	1908
Iron, Foundries and Nails	8	8	6	9	6
Machinery and Tools	20	16	19	17	30
Woolens, Carpets and Knit Goods	5	7	3	4	3
Cottons, Lace and Hosiery	1	2	1	2	2
Lumber, Carpenters and Coopers	40	46	44	42	84
Clothing and Millinery	60	64	60	57	64
Hats, Gloves and Furs	16	12	6	3	13
Chemicals and Drugs	1		1	3	4
Paints and Oils	1	4	1	2	5
Printing and Engraving	25	17	23	19	25
Milling and Bakers	35	23	25	41	29
Leather, Shoes and Harness	10	10	5	7	8
Liquors and Tobacco	12	12	15	15	19
Glass, Earthenware and Bricks	8	11	13	13	10
All other	130	130	101	87	132
Total Manufacturing	374	364	325	294	402

Traders	1913	1911	1910	1909	1908
General Stores	268	188	179	248	308
Groceries Meats and Fish	264	264	270	238	343
Hotels and Restaurants	62	38	52	43	87
Liquors and Tobacco	80	79	85	84	102
Clothing and Furnishing	198	162	134	119	146
Dry Goods and Carpets	146	121	75	85	144
Shoes, Rubbers and Trunks	51	45	38	35	46
Furniture and Crockery	35	33	24	28	39
Hardware Stoves and Tools	55	34	41	47	60
Chemicals and Drugs	47	38	41	36	48
Paints and Oils	2	18	5	2	5
Jewelry and Clocks	81	69	45	61	61
Books and Papers	11	9	11	9	11
Hats Furs and Gloves	11	8	5	5	8
All other	183	114	129	108	123
Total Trading	1463	1239	1113	1141	1471
Brokers and Transporters	60	50	52	36	74
Total Commercial	1897	1663	1510	1471	1949

Chart I

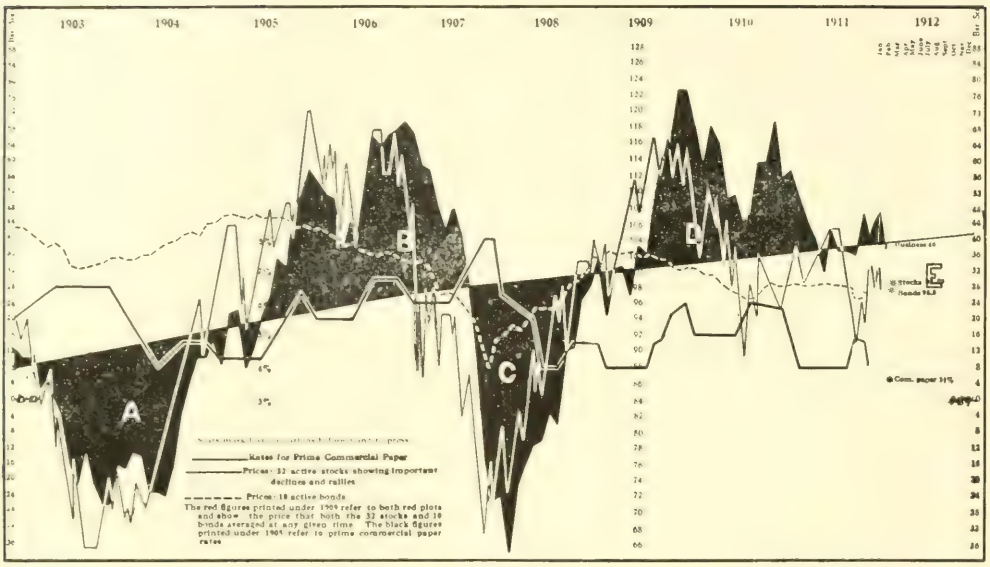

1903
1904
1905
1906
1907
1908
1909
1910
1911
1912
A
B
C
D
Rates for Prime Commercial Paper
Prices: 32 active stocks showing important declines and rallies
Prices: 10 active bonds
The red figures printed under 1904 refer to both red plots and show the price that both the 32 stocks and 10 bonds averaged at any given time. The black figures printed under 1905 refer to prime commercial paper rates

Chart 2

tions throughout the entire country. It is supplemented by detailed reports. Such maps and reports are supplying business news months before it appears in the public press and magazines.

In addition to this map, another is prepared which is also sent to the head of the corporation or firm showing the dark side of business, which may be termed the "Pessimistic Map." This indicates where business is poor, where the crops are uncertain, where failures are on the increase, and where credit conditions should be especially watched. Here again, if the corporation does other than a local business, the president can make further use of this map by turning it over to his credit department, enabling it to avoid the unfair and harmful system of "shutting down" on every body in all sections of the country to the same extent.

Instead of this the credit department may contract credits in one part of the country and possibly expand them in another section in a common sense and legitimate manner.

But although these maps are very useful for the purposes suggested above, yet their great value as an aid to the merchant is in anticipating future changes. Every period of depression and every period of prosperity which this or any other country has ever experienced has originated in some small section and spread in one or more directions from it. For this reason the merchant should keep in touch with business conditions the world-over. To illustrate some of the world-wide relations it may be interesting to see what the conditions are today (February 1912) in different places.

At the present time the greatest prosperity exists in Germany, and here is an abnormal condition liable to break like a bubble at any time; while the low pressure area, so to speak, is in our own country in a belt west of the Mississippi River, including the Dakotas, a part of Minnesota, extending down through Oklahoma into Texas and beginning to creep into the South. Whether or not we in this country are to have a panic or a depression cannot be told at the present time; but these conditions can be anticipated by studying the movement of such areas and noting whether the conditions in Germany break with a crash or whether they are gradually liquidated, whether the depression area throughout a portion of our West will work itself out in the South, or whether it will strike northward

to include Pennsylvania, New York and New England. The point that should be emphasized is that these changes can be anticipated by ascertaining conditions in different sections of the world at any time and the noticing the movements of the areas of low pressure and high pressure.

The Second Requisite is a Knowledge of the Volume of Business Including all Lines

In order to insure correctness in his forecasts, the successful merchant checks his conclusions as determined above by studying the volume of business, including all lines of trade. The money which you Boston merchants receive over your counter comes from other lines of business; the goods which you sell at a profit are sold to people in business different from your own. Therefore, your profits depend upon the prosperity of other lines rather than on the line in which you are directly interested.

Now, for obtaining a composite view of conditions in all lines, the merchant and manufacturer can take the figures on twelve leading subjects such as new building, bank clearings, immigration, failures, foreign trade, gold movements, crop statistics, idle cars, etc. The busy man, however, has not the time to pore over these figures, but desires to have them combined which is done in the Composite Plot of Business Conditions. (Chart II) This Composite Plot is in reality a trial balance of the United States, everything above the inclined line representing abnormal expansion, over-production, in fact the debit side of the ledger; while everything below the line represents contraction, rest, and the other items appearing on the credit side of the ledger. The outlines of the black areas represent the trend of business in this country and the last point at the right shows exactly where we are today. In other words, it may be seen that at the present time business is neither good nor bad, but it is poorer than it was a year ago, two years ago and three years ago, but much better than four years ago. In short, the Composite Plot of Business Conditions shows each week the volume of business being done throughout the country in all lines, the same as the maps show financial conditions in all sections.

Moreover, as by studying the movements of areas on Chart I one is able to anticipate changes, so by studying the variation in the volume on this composite plot from week to week, one may likewise anticipate conditions. This is owing to the fact that the law of action and reaction which applies to mechanics, medicine, astronomy and every other science applies also to business. Therefore for all that we go above the line of normal growth, there must be a corresponding amount—in area—below it. With this great principle firmly in mind and the charts in hand the merchant and manufacturer may anticipate with certainty the great trade tendencies.

As to what is to happen this week or next, or even this month or next, no one knows. You or I may apply to a life insurance company for a policy today, and we may be examined and shown to be in perfect health, and yet before night be run down by an automobile and killed; but when the insurance company considers all of its risks it can forecast with absolute certainty almost to a day what will be the average life of its policy holders, and it is the same with business. What will be the condition of your individual business, the next year or two, no merchant nor manufacturer can tell; but if he will take all of the business men together and treat them as one mass, the merchant and manufacturer who studies fundamental conditions, who studies conditions in all sections, and the total volume of all lines can tell with certainty by the use of these maps and these composite plots what will be the average business conditions.

On a clear day an object one foot above the level can be seen one and one third miles away. An object ten feet high can be seen at a distance of four miles.

CONSERVATION AND RESEARCH

LIGHT ENERGY AT HALF THE FORMER COST—WORK OF CANADIAN BUREAU OF MINES ON SMELTING IRON AND BRIQUETING PEAT—UTILIZING SMELTER GASES

BY H. T. KALMUS

STUDIES of conservation may be divided into two classes: those which pertain to wastes in connection with obtaining raw materials, and those which pertain to treatment and adaptation of these raw materials to utilize them as efficiently as possible. The former of these has received widespread attention, but the latter, which is essentially the work of the physical, the chemical, and the metallurgical research man, has been very little discussed. It is the purpose of this article to indicate some of the many ways in which the research laboratory has played an important part in conservation.

Most of the materials extracted from the earth have been exploited for thousands of years. However, the drafts upon the reserves of the earth as compared with its total capacity were small until the beginning of the nineteenth century. From the dawn of civilization until that time the amounts of fuels and metals mined had been so inconsiderable that it was thought that they would last through the indefinite future. Toward the latter half of the nineteenth century, began the age of scientific advance and invention, and of industrial and commercial operation on a large scale. Forecasts of the life of mineral resources made prior to that time became worthless in view of the tremendous acceleration at hand. Indeed, on this continent the output of the all-important products, coal and iron, has doubled in less than ten years which, computed in another way, means that the output of the first decade of this century has been more than that of all previous decades.

In his presidential address before the British Association for the Advancement of Science, Sir William Ramsay showed that, if the present increase in the output of coal mines in the British Isles continued, the supply would be exhausted in 175 years, a very brief space in a nation's life. We may no longer regard our coal supply as unlimited. In the year 1910 there were mined about 1300 million tons of coal. Of this, over 40 per cent. was produced on this continent and yet, according to Dr. J. A. Holmes, director of the United States Bureau of Mines, more than 2,000 million tons of anthracite coal and more than 3,000 million tons of bituminous coal have been left underground in such condition as to make its future recovery doubtful or impossible.

That there is tremendous waste in the mining of fuel supplies in North America is generally recognized, but its magnitude is almost inconceivable. In the mining of coal it is probable that scarcely 50 per cent. of it is removed from the ground and brought into such a form that it can be economically utilized. That portion which is left behind is undoubtedly lost forever, for the mines are allowed to cave in and probably can never be reopened. Of the need of this type of conservation we hear much in various reports, and the public at large are informed and are responding with liberal support in the movement towards betterment. But of the total energy in the portion of the coal made available for use, probably not over 11 per cent. is effectively utilized. The remainder of the energy is lost through the inefficiency of the steam boiler, the steam engine, and the electric dynamo. It is estimated that boiler scale on the locomotives of this continent alone, means an annual loss of over 16,000,000 tons of coal. One-sixteenth of an inch of boiler scale means a loss of 13 per cent. in efficiency, and one-eighth of an inch of

boiler scale, which occurs in many boilers, means a loss of 25 per cent. in efficiency. Here the research man directly effects an important conservation, although in such a way as not to be generally noticed, for an isolated investigator studying the chemistry of the deposition of boiler scale in his laboratory, is touching vitally the efficient utilization of our coal supplies.

Coal is being conserved by a great variety of heat insulating materials for lagging pipes, etc., which the chemist and the metallurgist have of late produced. The recent work of Dr. W. R. Whitney and his co-workers at the research laboratories of the General Electric Co., on the metal tungsten, has brought about an enormous conservation of coal resources. Until within recent years tungsten was considered a rare metal. Of late, because of its extremely high melting point, it became valuable as a substitute for platinum in the chemical laboratory. Now we find tungsten being drawn into fine wires for the manufacture of incandescent lamps on a colossal scale. In this way not only is the power consumer benefitted by the fact that replacing the old carbon filament with tungsten he gets the same amount of light energy at one-half the cost, but we have at the same time a direct wholesale saving of coal.

It is interesting to note the way in which researches on tungsten have effected real conservations in other ways. This hitherto almost worthless element has been found, when properly formed, to have properties far superior to those of any known metal for the manufacture of X-ray tubes. In modern X-ray practice powerful electrical apparatus is used to excite the tube. The greater part of the energy delivered to the tube is transformed into heat at the point where the cathode rays bombard a metallic target. Where platinum is used, which melts at 1755 degrees centigrade, it has been found necessary in order to prevent melting to place the target beyond the focus of the cathode, so as to spread the bombardment over a larger area. Without going into detail, this means at best an E-ray picture with poor definition due to the danger of melting the platinum. Tungsten, with a melting point of 3000 degrees centigrade, permits of sharp focussing of the rays on the target and of the use of more energy through the tube and, consequently, of a shorter exposure than has been hitherto possible. Aside from the direct value of this research on humanity, it obviously will substitute a new metal for the very limited and most costly one hitherto used, platinum, thus conserving the platinum for other uses where it alone can fulfil the requirements. The significance of this becomes obvious when we reflect that the production of platinum on this continent fell off about one-third during the past two years.

Ages ago there were stored up, chiefly by the influence of plant life, immense deposits of carbon and nitrogen, which have made modern civilization possible. Some of this nitrogen may have been compounded to its present useful form by electrical discharges in the atmosphere, but it is highly probable that the larger portion of it was formed of bacterial action. Certainly it appears to be true that the 500,000,000 tons of sodium nitrate, which are known to be deposited in the desert of Atacama, Chili, are of organic origin from plants and animals whose refuse, under peculiar conditions of heat and water supply, was oxidized and collected in this unique locality. Until recently we have drawn from these deposits practically our total supply of the element nitrogen, which is absolutely essential for both plant and animal food. Besides, we have drawn from this source all of the nitrogen without which we could not have explosives, upon which depends the whole of our mining industry. Our waste of nitrate as fertilizer has so impressed the human mind that the daily press for years has pointed out the possible starvation of man because of the inability of the earth to supply nitrate for plant life. 2,600,000 tons of sodium nitrate have been taken each year from Chili, which means that the depletion of these deposits is less than a century away. Yet, in the manufacture of coke, for the

various industries, but $3,800,000 worth of $160,000,000 worth of recoverable nitrogen which the original coal contained, was saved. The balance went off into the air as free nitrogen.

This nitrogen, among other things, is saved by the Germans under similar conditions, as the result of their researches. Until recently, practically all the coke made on the North American continent was produced in the old bee-hive type of coke oven, so called because of its similarity in shape to the conventional bee-hive. In this oven the coal is only partly consumed or, more accurately, the volatile combustible constituents, the gas, tar and ammonia, everything except the fixed carbon which is left behind as coke —is wasted. In comparatively recent years, a vast amount of research has been carried on in Germany, the outcome of which has been the saving of these various products by the development of the by-product oven, and the wonderful coal tar industry. This industry, which is probably the greatest example of chemical industrial progress, has as yet not been developed on this continent. It effects conservations in many ways; not generally noticed, but noteworthy among them, by producing an endless variety of dyes and coloring substances. All the aniline dyes are made from distillation products of coal. These formerly required rich land, now devoted to other purposes. Indigo alone, now prepared from coal tar, is equivalent to over 300,000 acres of indigo plants.

The research chemist has made possible the utilization of these by-products of the coke industry. He has, until recently, been appreciated only in Germany, but this continent is fast awakening to the reality of Germany's industrial progress, and research laboratories are making their appearance at the works of most of our progressive producers.

Passing to one of the largest of the industries, the iron and steel industry which produces, annually, on this continent over 20,000,000 tons of steel, we find that there is a loss of metal by oxidization during the metallurgical process which probably aggregates 1,000,000 tons. Along with this loss of iron many other elements more valuable than iron, which are needed in the final product, are burned out. When we contemplate this enormous amount of material and when we further contemplate that the production of the crude pig iron for this amount of steel represents an annual consumption of more than that many tons of coke, the importance of research to effect the most minute economy becomes obvious. The modern trend has been to study the possibilities of producing pig iron and steel in electric furnaces, the result of which is that considerable high-grade steel is now being made in this way. The Canadian Bureau of Mines, under the direction of Dr. Eugene Haanel, studied at length the production of pig iron from ore in electric furnaces and, as a result of this pioneer investigation, extensive work among the same lines was conducted at Trollhätten, Sweden, by the Swedish Iron-Masters Association. These experiments seem to show conclusively that where water power is cheap a conservation may be effected, and both pig iron and steel successfully manufactured on a commercial scale in electric furnaces.

Formerly, most of the slag from the iron and steel furnaces also went to waste, but in 1910 over 7,000,000 barrels of cement were produced on this continent from these slags. The Portland cement industry has had a tremendous effect upon the conservation of our natural resources, for not only has it supplied a cheap material to replace iron for many structural purposes, but it is also used as a coating to iron and steel, greatly increasing its life by preventing rusting. It is also taking the place of millions of feet of lumber, the demand for which of recent years, has been so rapidly depleting our forests.

A treatise may be written on conservation in connection with the iron and steel industry alone, but I wish only to point out a part played by the research man, which is not ordinarily apparent to the average reader. Where formerly carbon steel was used for certain electrical machinery, it is known that steel con-

taining a few per cent. of the element silicon will do the same work at a very substantial reduction in the power consumed. Here we have one of the most widespread of the elements, silicon, and one which, from a commercial point of view, is a drug on the market introduced in small quantities in a refined product to produce a steady permanent saving at the coal bin.

Professor G. Cotterell has spent years at painstaking research to produce a process for the electrical precipitation of suspended particles. The conservations that are being brought about by means of this are incalculable. Several large copper smelters in the western part of the continent were forced by the government to close down, owing to the devastation of the surrounding country from their sulphur fumes. One smelter alone in California emitted 250-500,000 cubic feet of poisonous gas per minute. It has adopted this new electrical process to the full capacity of its plant, and is now not only in a position to operate without injury to others, but it can save this flue gas for the production of sulphuric acid. Prof. C. L. Parsons, of the United States Bureau of Mines, points out that we discharge into the air from a single stack of the Washoe smelter, as much sulphuric acid as is utilized throughout the whole of the country, and yet this same acid is the basis of all chemical industries and of the manufacture of fertilizers.

Another recent development which promises much is that of the fixation of atmospheric nitrogen by the energy of the electric discharge. In this way there is made a compound of nitrogen available for use as fertilizer. Although this process is as yet rather inefficient, due to its high temperature and attendant heat loss, nevertheless, even this first approximation at a process has been eminently successful, reporting net earnings of $350,000 for the year 1911. It would certainly seem that if bacteria can bring about the fixation of nitrogen in the small laboratory they utilize at the roots of the legumes, man must sooner or later succeed in bringing it about at moderately low temperatures in his laboratories.

Only three years ago a leading scientific mind said, "The crest of our known resources of highest grade copper is already passed, and we are using lower and lower grades with increasing cost of production. The increasing inadequacy of our copper supply is a matter of deep concern." So rapid, however, has been the progress in the metallurgy of low-grade copper, that it is now proving more profitable to work than was previously the case with the high-grade ores. Indeed, although our production of copper has increased about 1000 per cent. in the last 25 years, and the annual output and consumption is still increasing, yet prices are lower than they were three years ago. This must all be credited to the greater efficiency of metallurgical processes making possible the utilization of deposits formerly supposed to be worthless.

Even this brief review of some of the important points at which the investigator touches the problems of conservation would be incomplete without mention of the recent and present work of Dr. Eugene Haanel and his associates of the Mines Branch, Ottawa, on peat. Peat is a material found in extensive bogs, in nearly every province of Canada. As removed from the bogs it is unsuitable for use as fuel, but after special treatment, including drying and briqueting, it makes excellent fuel. Some idea of the extent to which the utilization of this peat fuel deposit would conserve other forms of fuel, wood and coal, may be obtained from a recent low estimate of the peat resources of Canada as "equivalent to nearly sixteen million tons of coal."

These are a few of the savings in natural mineral resources which the research man has enabled those operating the various industries to bring about in recent years. Sometimes this saving is due to the utilization of new elements to replace old ones becoming exhausted; often it is brought about by supplying an entirely new compound or mechanism. Of the fifty metallic elements now known there were only seven in commercial use 2000 years ago, viz.: iron, copper, tin, gold, silver, mercury and lead. There

are eight others which were introduced into practical use between the 1st and 19th centuries, viz.: zinc, iridium, platinum, cobalt, nickel, antimony, cadmium and bismuth. That is, the rate of addition has been less than one metal for each two centuries prior to our century. Within our time, that is during the last twenty-five years, there have been about fourteen metals added to commercial use, or a rate more than one hundredfold greater than the previous rate.

A notion of the rapidity with which research has brought about changes in the various electro-chemical and metallurgical industries, is well illustrated by the statement of the president of one of our largest chemical corporations that "progress in chemical industries is taking place so rapidly through the study of new processes, introducing new machinery, new methods, and new materials, that my company has very little in the way of plant today which was in existence ten years ago.

HIGH VOLTAGE ELECTRIFICATION

An interesting further development in electrification of steam railroads is taking place in Montana. The Butte, Anaconda & Pacific Railway extending from Butte to Anaconda a distance of twenty-six miles, with a branch 8½ miles long to Stuart and one 4½ miles long to Butte Hill, is to be electrified. The Butte Hill branch is to be used for freight only and will continue to use steam for the present. The notable feature is the use of 2400-volt direct current locomotives. There are some direct current installations in Europe using 2400 volts or higher, and as high as 1500 volts is in use in this country, but this installation will be the first of any magnitude to utilize direct current of such high voltage.

Fifteen locomotives which weigh seventy-five tons each are being built to take care of the freight movement between Butte and Anaconda. This traffic consists principally of ore trains. The locomotives are to be double headed, hauling trains weighing 3500 tons (about 60 large ore cars) against a grade of about sixteen feet to the mile. Two additional electric locomotives of the same design as the others, except that they are geared for higher speed, will be used to haul regular passenger trains between the two cities. The railroad now employs twenty-eight steam locomotives, all of which will be replaced by electric locomotives with the exception of five which will be used temporarily on the Butte Hill branch until the whole electrification is completed.

The power will be furnished by the power company to two sub-stations which are located at Butte and Anaconda, respectively. The locomotives will draw their current from an overhead trolley. The advantage of high voltage is shown from the fact that the two sub-stations are located twenty-six miles apart and the amount of feeder wire is very moderate in spite of the size of the trains to be hauled. In ordinary 600-volt direct current trolley car work the proper distance apart of the sub-stations is about eight miles. As each sub-station requires considerable expensive machinery and a man constantly on hand to operate it, it will be seen that a considerable saving is effected by the use of higher voltage and consequently increased distance between sub-stations. L. E. M.

INDEX TO SCIENCE CONSPECTUS VOL. III

PAGE

Aërial Railways, Swiss 12
Atmosphere Is Made of, What The—Lecture by Sir William Ramsay, John Ritchie, Jr. .. 14
Bacteria and Protozoa, F. Schneider, Jr. 43
Blood Crystals Differ, How, L. E. Moore 13
Bowker, R. B., Problems of the Infinitely Little 146
Bridges, Diagram of the World's Largest 29
Brues, Charles T., Progress in a Puzzling Malady 19
Catalysis, The Phenomena of, W. R. Whitney 84
Chemotheraphy, Erlich's, Henry P. Talbot ... 122
Chimney, A Falling 126
Civilization, Doctors of, *Scientific American* .. 127
Clam Culture in Massachusetts, John Ritchie, Jr. 69
Combustion, Surface 128
Concerning the Crop of Scallops, John Ritchie, Jr. 114
Conservation in Japan 94
Doctors of Civilization, *Scientific American* .. 127
Doctrine of "Fitness," "The—Lecture by Prof. Lawrence J. Henderson, John Ritchie, Jr. 92
Doom of the Lobster, John Ritchie, Jr. 129
Dyar, Harrison G., Some Relations of Flies and Mosquitoes to Man 89
Early Man, Hervey W. Shimer 97
Elements of Fatigue, The, Percy G. Stiles 58
Erlich's Chemotherapy, Henry P. Talbot 122
Eugenics, The Importance of Negative, Woods Hutchinson 65
Falling Chimney, A 126
Fatigue, The Elements of, Percy G. Stiles 58
"Fitness," The Doctrine of—Lecture by Prof. Lawrence J. Henderson, John Ritchie, Jr. .. 92
Fergusson, S. P., Relation of Snow to Irrigation and Forestry 152
Flies and Mosquitoes to Man, Some Relations of, Harrison G. Dyar 89
Fly, Stable, Its Relation to Infantile Paralysis, C. T. Brues 19
Henderson, Prof. Lawrence J., Lecture by, The Doctrine of "Fitness," by John Ritchie, Jr. 92
Honest Label, An, A. G. Woodman 33
Horse, Gasolene and Electric Trucks 23
How Blood Crystals Differ, L. E. Moore 13
Hutchinson, Woods, The Importance of Negative Eugenics 65

PAGE

Importance of Negative Eugenics, The, Woods Hutchinson 65
Infantile Paralysis in Relation to the Stable Fly, Charles T. Brues 19
Infinitely Little, Problems of the, R. B. Bowker 146
Intensive Conservation in Japan 94
Japan, Intensive Conservation in. 94
Kitchen-Middens as Ethnological Records, H. W. Shimer 27
Label, An Honest, A. G. Woodman 33
Liquid Air as an Explosive, E. B. Spear 125
Lobster, Doom of the, John Ritchie, Jr. 129
Lowell, Percival, The Pyramids as an Astronomical Monument 75
Man, Early, Hervey W. Shimer 97
Moore, L. E., How Blood Crystals Differ 13
Mosquitoes and their Extermination, William Lyman Underwood 49
Nitrogen of the Air, Utilizing the, Arthur A. Noyes 8
Norton, John F., Swimming Pool Sanitation .. 158
Noyes, Arthur A., Utilizing the Nitrogen of the Air 8
Oysters, Shall We Eat Raw? Earl B. Phelps. 1
Phelps, Earle B., Shall We Eat Raw Oysters? 1
Phenomena of Catalysis, The, W. R. Whitney 84
Problems of the Infinitely Little, R. B. Bowker 146
Progress in a Puzzling Malady, Charles T. Brues 19
Protecting Public Health in Small Towns 96
Pyramids as an Astronomical Monument, The, Percival Lowell 75
Railways, Swiss Aërial 12
Relation of Snow to Irrigation and Forestry .. The, S. P. Fergusson 152
Ramsay, Sir William, Lecture by, What the Atmosphere Is Made of, John Ritchie, Jr. .. 14
Reviving a Dying Industry, John Ritchie, Jr 69
Ritchie, Jr., John, What the Atmosphere Is Made of,—Lecture by Sir William Ramsay, 14; The Doctrine of "Fitness"—Lecture by Prof. Lawrence J. Henderson, 92; Reviving a Dying Industry, 69; Concerning the Crop of Scallops 114; Doom of the Lobster 129
Rolfe, George W., Some Industrial Uses of Sugar 62
Scallops, Concerning the Crop of, John Ritchie, Jr. 114

	PAGE
Schneider, Jr., Franz, Bacteria and Protozoa	43
Shall We Eat Raw Oysters? Earle B. Phelps	1
[illegible]	97
Snow to Irrigation and Forestry, Relation of, [illegible]	152
Some Industrial Uses of Sugar, George W. Rolfe	62
Some Relations of Flies and Mosquitoes to Man, Harrison G. Dyar	89
Spear, E. B., Liquid Air as an Explosive	125
Stiles, Percy G., Ventilation from a New Standpoint, 31; The Elements of Fatigue	58
Sugar, Some Industrial Uses of, George W. Rolfe	62
[illegible]	128
Swimming Pool Sanitation, John F. Norton	158
Swiss Aërial Railways	12
Talbot, Henry P., Erlich's Chemotherapy	122
Trucks, Horse, Gasolene and Electric	23
Underwood, William Lyman, Mosquitoes and Their Extermination	49
Utilizing the Nitrogen of the Air, Arthur A. Noyes	8
Vaccines for Whooping Cough	145
Ventilation from a New Standpoint, Percy G. Stiles	31
What the Atmosphere Is Made of—Lecture by Sir William Ramsay, John Ritchie, Jr.	14
Whitney, W. R., The Phenomena of Catalysis	84
Whooping Cough, Vaccines for	145
Woodman, A. G., An Honest Label	33

OFFICERS OF THE SOCIETY OF ARTS 1912–1913

President of the Institute
RICHARD C. MACLAURIN

Secretary of the Society of Arts
ISAAC W. LITCHFIELD

Executive Committee

ELIHU THOMPSON
JAMES P. MUNROE
THE PRESIDENT
THEODORE N. VAIL
ARTHUR D. LITTLE
FREDERIC H. FAY
THE SECRETARY

LIST OF MEMBERS

Members are requested to inform the secretary of any change of address

THE CORPORATION

LIFE MEMBERS

Bowditch, Ernest W . . . . . 62 Devonshire Street, Boston, Mass.
*Carson, Howard A . . . . . 79 Glenwood Street, Malden, Mass.
Draper, Eben S. . . . . Hopedale, Mass.
du Pont, T. Coleman . . . . . Wilmington, Del.
**Endicott, William . . . . . 32 Beacon Street, Boston, Mass.
Estabrook, Arthur F . . . . . 15 State Street, Boston, Mass.
Felton, Samuel M. . . . . 1366 Dearborn Avenue, Chicago, Ill.
Fish, Frederick P . . . . . 84 State Street, Boston, Mass.
*FitzGerald, Desmond . . . . . 410 Washington Street, Brookline, Mass.
*Freeman, John R . . . . . Grosvenor Building, Providence, R. I.
*Hart, Francis R. . . . . Milton, Mass.
Higginson, Francis L. . . . . 274 Beacon Street, Boston, Mass.
*Hubbard, Charles W. . . . . 514 Shawmut Bank Building, Boston, Mass.
Lee, Elliot Cabot. . . . . Warren Street, Brookline, Mass.
Lincoln, William H. . . . . 1151 Tremont Building, Boston, Mass.
Livermore, Thomas L. . . . . 14 Ashburton Place, Boston Mass.
Longyear, John M. . . . . Leicester Street, Brookline, Mass.
*Lowell, A. Lawrence . . . . . Harvard University, Cambridge, Mass.
*Lowell, Percival. . . . . 53 State Street, Boston, Mass.
Mills, Hiram F. . . . . 266 Andover Street, Lowell, Mass.
*Munroe, James P . . . . . 79 Summer Street, Boston, Mass.
Peabody, Robert S. . . . . 22 The Fenway, Boston, Mass.
*Putnam, William Lowell . . . . . 60 State Street, Boston, Mass.
*Sewall, J. B. . . . . 1501 Beacon Street, Brookline, Mass.
Stearns, James P. . . . . National Shawmut Bank, Boston, Mass.
Stockton, Howard. . . . . 50 State Street, Boston, Mass.
*Stone, Charles A. . . . . 147 Milk Street, Boston, Mass.
*Thomson, Elihu . . . . . 42 Centre Street, West Lynn, Mass.
Thurber, William B. . . . . Milton, Mass.
*Tolman, James P. . . . . 88 Broad Street, Boston, Mass.
Tuttle, Lucius . . . . . 1120 Beacon Street, Brookline, Mass.
*Wigglesworth, George . . . . . 53 State Street, Boston, Mass.
*Williams, Francis H. . . . . 505 Beacon Street, Boston, Mass.

TERM MEMBERS OF THE CORPORATION

Term expires March, 1913

Rollins, James W., Jr. . . . . 6 Beacon Street, Boston, Mass.
*Morss, Everett . . . . . 201 Devonshire Street, Boston, Mass.
*Bradlee, Arthur T. . . . . 78 Chauncy Street, Boston, Mass.

Term expires March, 1914

Richards, Charles R. . . . . Cooper Union, New York, N. Y.
Snow, Walter B. . . . . 170 Summer Streer, Boston, Mass.
Robinson, Theodore W. . 1524 Commercial National Bank Building, Chicago, Ill.

*Associate member, Society of Arts. **Life member, Society of Arts.

Term expires March, 1915

Cunningham, Edward . . . . . 141 Milk Street, Boston, Mass.
Rollins, Frank W. . . . . John Hancock Building, Boston, Mass.
*Webster, Edwin S. . . . . P. O. Box 5304, Boston, Mass.

Term expires March, 1916

Howard, Henry . . . . . .36 Amory Street, Longwood, Mass.
*Morss, Henry A . . . . . 463 Commonwealth Avenue, Boston, Mass.
*Winslow, Arthur . . . . . .131 State Street, Boston, Mass.

Term expires March, 1917

Ferguson, Louis A. . . . . 1401 Davis Street, Evanston, Ill.
Little, Arthur D. . . . . .93 Broad Street, Boston, Mass.
Stevens, Eben S. . . . . Quinebaug, Conn.

ON THE PART OF THE COMMONWEALTH

The Honorable the COMMISSIONER OF EDUCATION
His Excellency the GOVERNOR
The Honorable the CHIEF JUSTICE OF THE SUPREME COURT

LIFE MEMBERS

Addicks, J. Edward . . . . . .1106 King Street, Wilmington, Del.
Beal, James H. . . . . 104 Beacon Street, Boston, Mass.
Breed, Francis W.. . . . . 45 Dana Street, Cambridge, Mass.
Coffin, F. S. . . . . .433 Walnut Street, Brookline, Mass.
Cross, Charles R. . . . . .Mass. Institute of Technology, Boston, Mass.
Endicott, William . . . . . 32 Beacon Street, Boston, Mass.
Griffin, Eugene . . . . . 44 Broad Street, New York, N. Y.
Hewins, Edmund H. . . . . 201 Devonshire Street, Boston, Mass.
Little, James L. . . . . Goddard Avenue, Brookline, Mass.
Little, John M. . . . . 317 Dartmouth Street, Boston, Mass.
Moore, Alexander . . . . . .11 Hamilton Place, Boston, Mass.
Parker, Walter E. . . . . Agent, Pacific Mills, Lawrence, Mass.
Pickering, E. C. . . . . Harvard College Observatory, Cambridge, Mass.
Rollins, William H. . . . . 250 Marlborough Street, Boston, Mass.
Sayles, Henry . . . . . 56 Commonwealth Avenue, Boston, Mass.
Sherwin, Thomas . . . . . Revere Street, Jamaica Plain, Mass.
Shurtleff, A. M. . . . . .9 West Cedar Street, Boston, Mass.
Tufts, John W. . . . . Camden, Me.
Ware, William R. . . . . Milton, Mass.
Watson, William . . . . . 107 Marlborough Street, Boston, Mass.
Whitaker, Channing . . . . . Lowell, Mass.
Wing, Charles H. . . . . .92 Brooks Street, Brighton, Mass.
Woodbury, C. J. H. . . . . .45 Milk Street, Boston, Mass.

ASSOCIATE MEMBERS

Alden, John . . . . . Lawrence, Mass.
Allen, Mrs. Thomas . . . . . 12 Commonwealth Avenue, Boston, Mass.
Allyn, Robert S. . . . . 16 Exchange Place, New York, N. Y.
Amster, N. L. . . . . .6 Hawes Street, Brookline, Mass.
Andrews, Clement W. . . . . .John Crerar Library, Chicago, Ill.
Andrews, Robert D. . . . . .50 Congress Street, Boston, Mass.
Appleton, Charles B. . . . . .Netherlands Road, Brookline, Mass.
Appleton, Francis Henry . . . . . 251 Marlborough Street, Boston, Mass.
Appleton, Wm. Sumner . . . . . 8 Park Street, Boston, Mass.
Arms, John T., Jr. . . . . .3 Spruce Street, Boston, Mass.
Armstrong, O. S. . . . . Riverside Press. Cambridge, Mass.
Atwood, Frank W. . . . . 216 Milk Street, Boston, Mass.
Ayer, Charles F. . . . . 141 Milk Street, Boston, Mass.
Baker, Day . . . . . 84 State Street, Boston, Mass.
Baldwin, George S. . . . . 27 State Street, Boston, Mass.
Bancroft, C. F. . . . . 84 State Street, Boston, Mass.
Barber, Albert G. . . . . 403 Washington Street, Boston, Mass.
Barbour, Edmund D. . . . . .610 Sears Building, Boston, Mass.
Bardwell, F. L. . . . . 1886 East 101st Street, Cleveland, Ohio.

Barnes, Herbert H. . . . . Hotel Brunswick, Boston, Mass.
Barron, C. W. . . . . 21 Exchange Place, Boston, Mass.
Barry, John L., Jr. . . . . 179 South Street, Boston, Mass.
Barstow, George E. . . . . 56 Graves Avenue, Lynn, Mass.
Bartlett, Dana P. . . . . Mass. Institute of Technology, Boston, Mass.
Bartlett, Francis . . . . . 40 State Street, Boston, Mass.
Bartlett, Spaulding . . . . . 7 Scott St., Cambridge, Mass.
Barton, Stephen E. . . . . 4 Liberty Square, Boston, Mass.
Bassett, William H. . . . . 146 Litchfield Street, Torrington, Conn.
Batcheller, Henry R. . . . . Box 21, Washington, N. H.
Batcheller, Robert . . . . . 723 15th Street, N. W., Washington, D. C.
Baxter, James Phinney . . . . . Portland, Me.
Baxter, Sylvester . . . . . Ledgewood Terrace, Malden, Mass.
Beasom, C. B. . . . . 248 Tremont Street, Newton, Mass.
Bemis, A. F. . . . . 89 State Street, Boston, Mass.
Bennett, Henry D. . . . . 85 Water Street, Boston, Mass.
Benson, Edward M. . . . . 101 Milk Street, Boston, Mass.
Bigelow, Homer L. . . . . Old Orchard Road, Chestnut Hill, Mass.
Bigelow, Robert P. . . . . Mass. Institute of Technology, Boston, Mass.
Binney, Amos . . . . . 526 Exchange Building, Boston, Mass.
Blake, Mrs. Arthur W. . . . . 450 Washington Street, Brookline, Mass.
Blake, Francis . . . . . Auburndale, Mass.
Blood, William H., Jr. . . . . 147 Milk Street, Boston, Mass.
Bort, Robert A. . . . . 40 Kilby Street, Boston, Mass.
Brackett, Dexter . . . . . 712 Washington Street, Brighton, Mass.
Bradlee, Arthur T. . . . . Chestnut Hill, Mass.
Braley, Samuel T. . . . . Rutland, Vt.
Brewer, Edward M. . . . . 40 Churchill Lane, Milton, Mass.
Brophy, William . . . . . 17 Egleston Street, Jamaica Plain, Mass.
Brown, C. Leonard . . . . . 38 Wallace Street, W. Somerville, Mass.
Brown, Dickson Q. . . . . 11 Broadway, New York, N. Y.
Brown, Samuel N. . . . . 119 Commonwealth Avenue, Boston, Mass.
Brown, Walter S. . . . . Underhill Center, Vt.
Bryden, George W. . . . . 47 Prospect Ave., Winthrop, Mass.
Buchanan, L. B. . . . . 147 Milk Street, Boston, Mass.
Burns, Peter S. . . . . Milton, Mass.
Cameron, J. A. . . . . Forge Village, Mass.
Carruth, Charles T. . . . . 4 Fayerweather Street, Cambridge, Mass.
Carson, Howard A. . . . . 79 Glenwood St., Malden, Mass.
Carty, John J. . . . . 15 Dey Street, New York, N. Y.
Chandler, F. W. . . . . 195 Marlborough Street, Boston, Mass.
Chase, F. D. . . . . Smelter No. 2, Monterey, Mexico.
Claflin, George E. . . . . 47 Ames Building, Boston, Mass.
Clapp, George A. . . . . 49 Federal Street, Boston, Mass.
Clark, Myron H. . . . . 7 Glen Rock Circle, Malden, Mass.
Clarke, Alfred . . . . . 131 State Street, Boston, Mass.
Clarke, Ralph S. . . . . 35 Rockwell Street, Dorchester Center, Mass.
Clifford, H. E. . . . . Harvard University, Cambridge, Mass.
Coburn, Howard L. . . . . 83 Newbury Street, Boston, Mass.
Codman, J. S. . . . . 93 Broad Street, Boston, Mass.
Coffin, C. A. . . . . 145 West 58th Street, New York, N. Y.
Cole, L. L. . . . . 32 Franklin Street, Boston, Mass.
Collier, Arthur L. . . . . 26 Baker Ave., Beverly, Mass.
Collins, R. B. . . . . 21 Elam Place, Buffalo, N. Y.
Colson, Warren H. . . . . 184 Boylston Street, Boston, Mass.
Colt, James D. . . . . 53 State Street, Boston, Mass.
Connor, James T. . . . . 23 Englewood Street, Dorchester, Mass.
Cook, Charles S. . . . . 24 Winter Street, Boston, Mass.
Cook, Thomas N. . . . . 189 Congress Street, Boston, Mass.
Copeland, William A. . . . . 365 Hammond Street, Chestnut Hill, Mass.
Crafts, J. Chancellor . . . . . 77 Lanark Road, Brookline, Mass.
Crafts, James M. . . . . 111 Commonwealth Avenue, Boston, Mass.
Crane, Charles K. . . . . Dalton, Mass.

Cress, Leonidas H. . . . .Brae Burn Country Club, West Newton, Mass.
Crosby, William O. . . . . .9 Park Lane, Jamaica Plain, Mass.
Crosby, William W. . . . . .53 State Street,Boston, Mass.
Currier, Guy W. . . . . 84 State Street, Boston, Mass.
Curtis, Henry P. . . . . .The Lenox, Boston, Mass.
Cutter, Louis F. . . . . .33 Chestnut Street, Salem, Mass.
Dabney, Herbert . . . . . .45 Broad Street, Boston, Mass.
Dana, Gorham . . . . . 17 Edge Hill Road, Brookline, Mass.
Daniels, Alanson L. . . . . 60 Congress Street, Boston, Mass.
Danker, Daniel J. . . . . 13 Dean Road, Brookline, Mass.
Darling, Henry E . . . . . .15 Dey Street, New York, N. Y.
Davis, Edmund S . . . . . .15 Beacon Street, Boston, Mass.
Davis, Edward W. . . . . .152 Purchase Street, Boston, Mass.
Davis, Nelson C., M. D. . . .Care of H. P. Hood & Sons, Charlestown, Mass.
Davy, J. Winsor . . . . . .301 Equitable Building, Boston, Mass.
Day, Frank A. . . . . .35 Congress Street, Boston, Mass.
Day, Nathan B. . . . . 280 Newbury Street, Boston, Mass.
Defren, George . . . . . .289 Park Street, Newton, Mass.
Dennison, Henry S. . . . . South Framingham, Mass.
Densmore, Edward D. . . . . .26 Downing Road, Brookline, Mass.
Dodd, John W. . . . . 3 Auburn Court, Brookline, Mass.
Dodge, Chester P. . . . . Rockport, Mass.
Doherty, P. J. . . . . .95 Milk Street, Boston, Mass.
Donlan, Charles E. . . . . Long Island Hospital, Boston Harbor, Mass.
Dowse, William B. H. . . . . .95 Milk Street, Boston, Mass.
Dudley, P. H. . . . . .Grand Central Station, New York, N. Y.
Dunbar, W. O. . . . . .1218 13th Street, Altoona, Pa.
Emerson, Guy C. . . . . 4 Brewer Street, Jamaica Plain, Mass.
Emery, Frederick L. . . . . 50 Congress Street, Boston, Mass.
Emery, Ralph C. . . . . .114 State Street, Boston, Mass.
Eustis, F. A. . . . . .131 State Street, Boston, Mass.
Eustis, J. P. . . . . .Ames Street, Cambridge, Mass.
Eustis, W. E. C. . . . . .131 State Street, Boston, Mass.
Eynon, John S. . . . . .20 Kilby Street, Boston, Mass.
Farrington, Charles E. . . . . .200 Summer Street, Boston, Mass.
Fay, Frederic H. . . . . .60 City Hall, Boston, Mass.
Fish, Charles H. . . . . P. O. Box 1352, New York, N. Y.
Fisher, Andrew, Jr. . . . . .108 E. River Street, Hyde Park, Mass.
FitzGerald, Desmond . . . . . Brookline, Mass.
FitzGerald, Francis A. J.. FitzGerald & Bennie Laboratories, Niagara Falls, N. Y.
Flather, Frederick A. . . . . .68 Mansur Street, Lowell, Mass.
Fobes, Edwin F. . . . . .3 Chandler Street, Lexington, Mass.
Foss, E. N.. . . . . .11 Revere Street, Jamaica Plain, Mass.
Foss, Herbert D. . . . . .11 Linnaean Street, Cambridge, Mass.
Fox, Charles K. . . . . Haverhill, Mass.
Freeman, John R. . . . . .Grosvenor Building, Providence, R. I.
French, E. V. . . . . .31 Milk Street, Boston, Mass.
Fuller, Charles E. . . . . Mass. Institute of Technology, Boston, Mass.
Fuller, George W. . . . . 170 Broadway, New York, N. Y.
Gallagher, H. C. . . . . 45 Broad Street, Boston, Mass.
Garfield, A. S. . . . . 10 rue de Londres, Paris, France.
Gilley, Frank M. . . . . 21 John Street, Chelsea, Mass.
Gilman, Wesley C. . . . . 13 Exchange Street, Lynn, Mass.
Gleason, Gilbert H. . . . . 12 Pearl Street, Boston, Mass.
Goddard, Morrill . . . . . 2 Duane Street, New York, N. Y.
Goodell, George H., Care Rank & Goodell, Pioneer Press Building, St. Paul, Minn.
Goodspeed, Joseph H. . . . . .279 Newbury Street, Boston, Mass.
Gray, Joseph P. . . . . Box 112, Boston, Mass.
Greenleaf, Lewis S. . . . .Care Hudson River Telephone Co., Albany, N. Y.
Grover, Nathan C. . . . . .1330 F Street, N. W., Washington, D. C.
Gunisburg, A. M. . . . . .Medway, Mass.
Gyzander, C. R. . . . . .Cochrane Chemical Co., Everett, Mass.
Hale, Richard A. . . . . Lawrence, Mass.

Hamblet, George W. . . . . 506 Lowell Street, Lawrence, Mass.
Hamilton, George Wyman . . . . . 30 Tremont Street, Boston, Mass.
Hardwick, Harry M. . . . . 40 King St., Roxbury, Mass.
Hart, Francis R. . . . . Milton, Mass.
Hartness, James . . . . . Springfield, Vt.
Hawkins, Edgar M. . . . . 100 Park Avenue, Rochester, N. Y.
Hayes, Hammond V. . . . . 101 Milk Street, Boston, Mass.
Hazen, Allen . . . . . 103 Park Avenue, New York, N. Y.
Henderson, Charles W., Jr. . . . . 374 Congress Street, Boston, Mass.
Henderson, F. C. . . . . 228 Clinton Road, Brookline, Mass.
Herrick, Rufus F. . . . . 16 Herrick Street, Winchester, Mass.
Hill, William H. . . . . 50 Congress Street, Boston, Mass.
Hobart, John D. . . . . Malden, Mass.
Hobbs, Franklin W. . . . . Brookline, Mass.
Hodgdon, Frank W. . . . . 18 Wellington Street, Arlington, Mass.
Hofman, H. O. . . . . Mass. Institute of Technology, Boston, Mass.
Holden, George W. . . . . 895 Boylston Street, Boston, Mass.
Hollis, Frederick S. . . . . 640 Woodruff Middle Drive, Indianapolis, Ind.
Holman, G. M. . . . . 52 Pleasant Street, Fitchburg, Mass.
Holst, E. W. . . . . Post Office Box 2072, Boston, Mass.
Holton, Edward C. . . . . 104 Canal Street, Cleveland, Ohio.
Holtzer, Charles W. . . . . Brookline, Mass.
Hopewell, Charles F. . . . . 42 Osborne Street, Cambridge, Mass.
Hopkins, Woodworth . . . . . 123 Westmorley Court, Cambridge, Mass.
Horton, Theodore . . . . . State Department of Health, Albany, N. Y.
Howe, Henry M. . . . . Broad Brook Road, Bedford Hills, New York, N. Y.
Hubbard, Charles W. . . . . 55 Congress Street, Boston, Mass.
Humphrey, S. K. . . . . 83 Newbury Street, Boston, Mass.
Hunneman, W. C. . . . . 94 Colchester Street, Brookline, Mass.
Hunsaker, Jerome C . . . . . 1677 Beacon Street, Brookline, Mass.
Huse, Frank J. . . . . 2624 Thayer Street, Evanston, Ill.
Jackson, Charles C. . . . . 19 Congress Street, Boston, Mass.
Jackson, Dugald C. . . . . Mass. Institute of Technology, Boston, Mass.
Jackson, Henry D. . . . . 88 Broad Street, Boston, Mass.
James, Frank M. . . . . 518 West 145th Street, New York, N. Y.
Jenks, William J. . . . . Room 1923, 30 Church Street, New York, N. Y.
Johnson, Henry L. . . . . 336 Metropolitan Avenue, Roslindale, Mass.
Johnson, Jesse F. . . . . 6 Grosvenor Apts., Montreal, Can.
Johnson, William S. . . . . 101 Tremont Street, Boston, Mass.
Jones, Jerome . . . . . 33 Franklin Street, Boston, Mass.
Jones, Milton F. . . . . 71 Kilby Street, Boston, Mass.
Jonsberg, Frank F. . . . . 733 Old South Building, Boston, Mass.
Jordan, N. W. . . . . 53 State Street, Boston, Mass.
Keep, Florence A. . . . . 2251 R. Street, N. W., Washington, D. C.
Keith, Herbert J. . . . . 72 South Market Street, Boston, Mass.
Keith, Simeon C., Jr. . . . . 394 Rutherford Avenue, Charlestown, Mass.
Keller, Carl Tilden, ... 50 Oliver Street, Boston, Mass.
Keller, Jasper N. . . . . 50 Oliver Street, Boston, Mass.
Kimball, Fred M. . . . . 49 Elmhurst Road, Newton, Mass.
Kimball, George A. . . . . 101 Milk Street, Boston, Mass.
Kimball, Joseph H. . . . . 620 Equitable Building, Louisville, Ky.
Kimball, W. F. . . . . 7 Beals Street, Brookline, Mass.
Knight, A. S. . . . . 309 Sears Building, Boston, Mass.
Knights, Arthur A. . . . . 100 Beacon Street, Worcester, Mass.
Lanza, Gaetano . . . . . The Montevista, 63d & Oxford Sts., Philadelphia, Pa.
Lauman, William H. . . . . 165 Broadway, New York, N. Y.
Lawrence, Ralph R. . . . . Mass. Institute of Technology, Boston, Mass.
Lawrence, William H. . . . . Mass. Institute of Technology, Boston, Mass.
Laws, Frank A. . . . . Mass. Institute of Technology, Boston, Mass.
Learned, Isaac N. . . . . 674½ Tremont Street, Boston, Mass.
Leavitt, E. D. . . . . 33 Garden Street, Cambridge, Mass.
Lee, John C. . . . . Longwood, Mass.
Leland, Walter S. . . . . 815 Balboa Building, San Francisco, Cal.

Leverett, George V. . . . . 66 Beacon Street, Boston, Mass.
Lincoln, Miss A. W. . . . . Lincoln Road, Medford, Mass.
Lincoln, E. S. . . . . 132 Summit Avenue, Brookline, Mass.
Litchfield, Isaac W. . . . . Mass. Institute of Technology, Boston, Mass.
Little, A. D. . . . . 93 Broad Street, Boston, Mass.
Lockett, Kenneth . . . . . 5116 Madison Avenue, Chicago, Ill.
Lodge, H. Ellerton . . . . . Post Office Box 2228, Boston, Mass.
Lodge, Richard W. . . . . Post Office Box 84, Redlands, Cal.
Longley, Edmund W. . . . . 318 Lafayette Street, Salem, Mass.
Lonngren John E. . . . Supt. Wire Mills, Cambria Steel Co., Johnstown, Pa.
Lord, Charles E. . . . . 24 Milk Street, Boston, Mass.
Loring, Lindsey . . . . . Fox Hill Street, Westwood, Mass.
Loud, Joseph P. . . . . 85 Water Street, Boston, Mass.
Lovell, Fred W. . . . . 69 Mt. Vernon Street, North Cambridge, Mass.
Lowe, A. W. . . . . 1 Olive Street, Lynn, Mass.
Lowell, A. Lawrence . . . . . Harvard University, Cambridge, Mass.
Lowell, James A. . . . . Chestnut Hill, Mass.
Lowell, Percival . . . . . 53 State Street, Boston, Mass.
Lyman, Arthur T. . . . . Post Office Box 1717, Boston, Mass.
Lythgoe, Hermann C. . . . . Room 501, State House, Boston, Mass.
McCarter, F. W. . . . . 17 Lewis Wharf, Boston, Mass.
McClench, William W. . . . . Springfield, Mass.
McClosky, J. Frederick . . . . United Shoe Machinery Co., Beverly, Mass.
MacElwain, J. Franklin . . . . . 39 Chestnut Street, Boston, Mass.
McJunkin, Paul . . . . . 201 East 16th Street, New York, N. Y.
Main, Charles T. . . . . 201 Devonshire Street, Boston, Mass.
Marsh, William P. . . . . 10 Laurel Street, Waverley, Mass.
Martin, Henry. . . . . 8 Pine Street, Glen Falls, N. Y.
Mellen, Edwin D. . . . . 1590 Massachusetts Avenue, Cambridge, Mass.
Melluish, James G. . . . . 222 Unity Building, Bloomington, Ill.
Merrill, S. M. . . . . 120 Boylston Street, Boston, Mass.
Metcalf, Leonard . . . . . 14 Beacon Street, Boston, Mass.
Miles, George W. . . . . 29 Central Street, Boston, Mass.
Mills, Harrison W. . . . . 7 Produce Exchange, Boston, Mass.
Minns, Miss Susan . . . . . 14 Louisburg Square, Boston, Mass.
Moody, Frederick C. . . . Kansas & Missouri Telephone Co., Kansas City, Mo.
Moore, Fred F. . . . . Post Office Box 81, Hawthorn, N. Y.
Morss, Everett . . . . . 201 Devonshire Street, Boston, Mass.
Morss, Henry A. . . . . 463 Commonwealth Avenue, Boston, Mass.
Morss, John Wells . . . . . 201 Devonshire Street, Boston, Mass.
Mosman, Philip A. . . . . 165 Broadway, New York , N. Y.
Mulliken, Samuel P. . . . . Mass. Institute of Technology, Boston, Mass.
Munroe, James P. . . . . Room 62, 79 Summer Street, Boston, Mass.
Musolino, A. . . . . Wilmington, Mass.
Neall, N. J. . . . . 12 Pearl Street, Boston, Mass.
Norris, Albert P. . . . . 760 Massachusetts Avenue, Cambridge, Mass.
North, Isaac F. . . . . 70 Montvale Road, Newton Centre, Mass.
Northey, Edward A. . . . . 70 Kilby Street, Boston, Mass.
Norton, Edward E. . . . . 105 Chauncy Street, Boston, Mass.
Noyes, Arthur A. . . . . Mass. Institute of Technology, Boston, Mass.
Nutter, H. G. . . . . Court House, Chelsea, Mass.
Nutter, R. H. . . . . Post Office Box 272, Lynn, Mass.
Nutting, George H. . . . . 119 Aldrich Street, Boston, Mass.
O'Connell, P. A. . . . . 155 Tremont Street, Boston, Mass.
Ohlson, Olof . . . . . 472 Crafts Streets, West Newton, Mass.
Osborne, George A. . . . . Mass. Institute of Technology, Boston, Mass.
Paine, William A. . . . . 82 Devonshire Street, Boston, Mass.
Patterson, George W. . . . . University of Michigan, Ann Arbor, Mich.
Peabody, C. H. . . . . Mass. Institute of Technology, Boston, Mass.
Peacock, Samuel . . . . . 725 South 60th Street, Philadelphia, Pa.
Pendergast, Roland B. . . . . 48 Beacon Street, Boston, Mass.
Phillips, A. V. . . . . 89 State Street, Boston, Mass.

Pickert, Leo W. . . . . 16 New Street, East Boston, Mass.
Pollock, Clarence D. . . . . Calle Cuba 24, Havana, Cuba.
Pope, T. E. . . . . Mass. Institute of Technology, Boston, Mass.
Porter, Dwight . . . . . Mass. Institute of Technology, Boston, Mass.
Powers, W. C. . . . . 155 Pearl Street, Boston, Mass.
Pratt, Herbert G. . . . . 56 Bellevue Street, Newton, Mass.
Prescott, Samuel C. . . . . Mass. Institute of Technology, Boston, Mass.
Proctor, Henry H. . . . . 282 Commonwealth Avenue, Boston, Mass.
Putnam, William Lowell . . . . . 49 Beacon Street, Boston, Mass.
Quimby, C. N. . . . . 60 Hillside Avenue, Arlington Heights, Mass.
Radway, Sarah E. . . . . 67 Beacon Street, Boston, Mass.
Raeburn, Andrew . . . . . Room 47, 70 Kilby Street, Boston, Mass.
Reardon, T. F. E. . . . . Hotel Longfellow, West Lynn, Mass.
Rees, John E. . . . . Tendoy, Idaho.
Reynolds, Howard, S. . . . . Ludlow Manufacturing Co., Ludlow, Mass.
Rice, Charles E. . . . . 112 Canal Street, Boston, Mass.
Rich, Isaac . . . . . 36 Walnut Street, Somerville, Mass.
Richards, Miss Alice A. . . . . 98 Colchester Street, Brookline, Mass.
Richards, R. H. . . . . Mass. Institute of Technology, Boston, Mass.
Riley, Charles E. . . . . 93 Bellevue Street, Newton, Mass.
Roberts, George L. . . . . 95 Milk Street, Boston, Mass.
Robinson, B. Atwood. . . . . 216 High Street, Boston, Mass.
Robinson, Edward P. . . . . 80 Border St., E. Boston, Mass.
Rogers, Miss Annette P. . . . . 5 Joy Street, Boston, Mass.
Rolfe, George W. . . . . Mass. Institute of Technology, Boston, Mass.
Royce, Frederick P. . . . . Common Street, Dedham, Mass.
Sanborn, Frank E. . . . . Ohio State University, Columbus, Ohio.
Sando, Will J. . . . . Allis-Chalmers Co., Milwaukee, Wis.
Sauveur, Albert . . . . . Hatch Building, Cambridge, Mass.
Sawtelle, William O. . . . . 4 Mercer Circle, Cambridge, Mass.
Sawyer, Albert H. . . . . 19 Pearl Street, Boston, Mass.
Sawyer, Alfred H. . . . . 237 West Newton Street, Boston, Mass.
Schneider, Theophile . . . . . 280 Dartmouth Street, Boston, Mass.
Schonler, James . . . . . 2 Newbury Street, Boston, Mass.
Schrafft, William E. . . . . 16 Charlestown Bridge, Boston, Mass.
Schwamb, Peter . . . . . 33 Academy Street, Arlington, Mass.
Sears, Horace S. . . . . Weston, Mass.
Sears, Russell A. . . . . 101 Milk Street, Boston, Mass.
Sewall, J. B. . . . . 1501 Beacon Street, Brookline, Mass.
Shattuck, A. Forrest . . . . . The Solvay Process Co., Detroit, Mich.
Shaw, Henry S. . . . . Milton, Mass.
Sherman, George W. . . . . Akron, Ohio.
Shuman, A. . . . . 440 Washington Street, Boston, Mass.
Shute, George P. . . . . P. O. Box P. Jersey City, N. J.
Slater, H. C. . . . . Post Office Box 102, Ridley Park, Pa.
Smith, Harrison W. . . . . Mass. Institute of Technology, Boston, Mass.
Smith, Hubert S. . . . . 215 Newbury Street, Boston, Mass.
Smith, John W. . . . . 7 Brookfield Street, Roslindale, Mass.
Snow, F. Herbert . . . . . State Department of Health, Harrisburg, Pa.
Snyder, Frederic S. . . . . 55 Blackstone Street, Boston, Mass.
Sohier, William D. . . . . 79 Beacon Street, Boston, Mass.
Solomont, James . . . . . 41 Georgia Street, Roxbury, Mass.
Spear, Walter E. . . . . 250 West 54th Street, New York, N. Y.
Spinney, Frank C. . . . . 636 Beacon Street, Boston, Mass.
Sprague, Isaac . . . . . Post Office Box 3134, Boston, Mass.
Stantial, F. G. . . . . Care Cochrane Chemical Co., Everett, Mass.
Stearns, Frederic P. . . . . 1 Ashburton Place, Boston, Mass.
Stearns, F. W. . . . . 269 Park Street, Newton, Mass.
Stevens, Walter F. . . . 1190 Boylston Street, Newton Upper Falls, Mass.
Stoddard, George H. . . . . 133 Commercial Street, Boston, Mass.
Stone, Charles A. . . . . Post Office Box 5304, Boston, Mass.
Stone, John S. . . . . 31 State Street, Room 906, Boston, Mass.
Sullivan, P. F. . . . . 84 State Street, Boston, Mass.

Sully, John M. . . . . Chino Copper Co., Santa Rita, N. M.
Summer, John O. . . . . Mass. Institue of Technology, Boston, Mass.
Suter, Russell . . . . . State Water Supply Commission, Albany, N. Y.
Swain, George F. . . . . Harvard University, Cambridge, Mass.
Sweet, H. N. . . . . 63 Mt. Vernon Street, Boston, Mass.
Talbot, Henry P. . . . . Mass. Institute of Technology, Boston, Mass.
Taylor, R. R. . . . . Tuskegee Institute, Tuskegee, Ala.
Thomson, Elihu . . . . . 42 Centre Street, West Lynn, Mass.
Thorp, Frank H. . . . . Mass. Institute of Technology, Boston, Mass.
Thorpe, Gardner E. . . . . Post Office Box 33, Boston, Mass.
Tillinghast, Charles F. . . . . 260 Angell Street, Providence, R. I.
Tinkham, S. Everett . . . . . 65 City Hall, Boston, Mass.
Tolman, James P. . . . . 88 Broad Street, Boston, Mass.
Traiser, Charles H. . . . . 530 Beacon Street, Boston, Mass.
Travis, George C. . . . . 101 Milk Street, Boston, Mass.
Tripp, Thaxter N. . . . . 11 Baltimore Street, Lynn, Mass.
Tucker, G. R. . . . . 68 Northampton Street, Boston, Mass.
Turner, E.K. . . . . 53 State Street, Boston, Mass.
Turner, Everett P. . . . . Arlington, Mass.
Turner, Howard C. . . . . 386 Commonwealth Avenue, Boston, Mass.
Tyler, Harry W. . . . . Mass. Institute of Technology, Boston, Mass.
Underwood, George R. . . . . Peabody, Mass.
Underwood, W. Lyman . . . . . Belmont, Mass.
Vail, Theodore N. . . . . Lyndonville, Vt.
Vaillant, George W. . . . . 53 State Street, Boston, Mass.
Van Nostrand, A. G. . . . . 482 Beacon Street, Boston, Mass.
Vesper, Robert A. . . . . 89 Waldeck Street, Dorchester Center, Mass.
Wachter, Carl . . . . . 390 Harvard Street, Cambridge, Mass.
Wadleigh, Horace W. . . . . 234 Commonwealth Avenue, Boston, Mass.
Walker, Charles R. . . . . 47 Wendell Street, Cambridge, Mass.
Walker, John B. . . . . 70 State Street, Boston, Mass.
Walker, William H. . . . . Mass. Institute of Technology, Boston, Mass.
Ware, Horace E. . . . . 110 Summer Street, Boston, Mass.
Warren, Henry E. . . . . The Lombard Governor Co., Ashland, Mass.
Washburn, Thomas G. . . . . 68 Pemberton Square, Boston, Mass.
Wason, Leonard C. . . . . 1 Summit Avenue, Brookline, Mass.
Webster, David L. . . . . 134 Summer Street, Boston, Mass.
Webster, Edwin S. . . . . Box 5304, Boston, Mass.
Wells, Webster . . . . . The Beaconsfield, Brookline, Mass.
Wesson, Paul B. . . . . Lowell Machine Shop, Lowell, Mass.
Weston, David B. . . . . Sharon, Mass.
Wheelright, Henry M. . . . . Union Street, Ware, Mass.
Whipple, George C. . . . . 103 Park Avenue, New York, N. Y.
Whitman, William . . . . . Box 100, Essex Street Station, Boston, Mass.
Whitney, Hammond M. . . . . 39 Carleton Street, Brookline, Mass.
Wiggin, Thomas H. . . . . 165 Broadway, New York, N. Y.
Wigglesworth, George . . . . . Room 1004, 53 State Street, Boston, Mass.
Wilder, S. W. . . . . 33 Broad Street, Boston, Mass.
Williams, Albert P. . . . . 278 Crescent Street, Waltham, Mass.
Williams, Dr. Francis H. . . . . 505 Beacon Street, Boston, Mass.
Williams, Henry J. . . . . 161 Tremont Street, Boston, Mass.
Wilson, Charles E. . . . . 11 Central Avenue, Lynn, Mass.
Wilson, H. Carlos . . . . . Lewis Wharf, Boston, Mass.
Wilson, John F. . . . . 90 Chauncy Street, Boston, Mass.
Winslow, Arthur . . . . . 18 Chestnut Street, Boston, Mass.
Winsor, Paul . . . . . 101 Milk Street, Boston, Mass.
Wood, Henry B. . . . . 35 Myrtle Street, Belmont, Mass.
Woodbridge, S. H. . . . . Mass. Institute of Technology, Boston, Mass.
Woodwell, J. E., Terminal Building, Park Avenue and 41st Street, New York, N. Y.

SCIENCE CONSPECTUS

VOL. III DECEMBER, 1912 No. 1

SHALL WE EAT RAW OYSTERS?

SOME FACTS ABOUT THE LIFE, HABITS AND SURROUNDINGS OF THE OYSTER AND AN INQUIRY INTO THE SERIOUS CHARGES MADE AGAINST IT

BY EARLE B. PHELPS

THE oyster is a nutritious, wholesome and economical food, or it is a positive menace to the health of the community, according to the particular side of the question which one happens to read. In the daily press, in the magazines, and before meetings of learned societies, the oyster question is being discussed with an enthusiasm that is not always tempered with exact knowledge, or with a regard for the finer niceties of logic. It often happens that the innocent onlooker suffers more seriously than the active combatants and it is especially so in this case. The humble seeker after knowledge learns that oysters are contaminated, that oysters are safe, that he must know the source of the oysters he eats, that oysters are good in one month and bad in another. In despair, he either abandons oysters, or eats oysters and abandons hope.

The time seems opportune, therefore, for a brief statement of the known facts about the oyster's life habits and surroundings, and an inquiry into the serious charges made against it.

The oyster begins his life, in our northern waters, about the middle of August as a free swimming microscopic organism at the surface of the sea. After enjoying a few days of travel, he settles down upon the bottom and in the great majority of cases his life history is completed. If by good fortune he finds himself at rest upon some hard surface, which prevents his sinking into the muddy bottom, he immediately attaches himself to that surface and proceeds to grow. Old oyster shells form the most favorable substratum for his future development, but boulders, tin cans and even bits of wood will serve. At this stage of his life, the oyster is barely visible, and appears as a small brownish spot upon the white surface of the shell (figure 1). His growth is rapid now. Within a week he has attained a diameter of a quarter of an inch and appears as in figure 2. One week later he is nearly one-half inch across as in figure 3, while at the end of five weeks he has attained the dimensions of a five-cent piece, and has begun to feel somewhat crowded upon the old shell as figure 4 shows.

At this age the oysters are known as "oyster seed" and are an established article of commerce. Clean shells are spread upon favorable bottoms to secure a "catch" of the spat. These are later removed from the bottom and often shipped hundreds of miles to be replanted.

Under the laws of most of the oyster-growing states, oyster ground may be leased from the state for the purpose of securing seed or of raising mature oysters. Seed is also gathered from natural beds, especially in the south. After the first winter, the young oyster grows more slowly, and in northern waters requires three years for development to market size. During this time, however, the growing beds are frequently worked over by dredges in order to break up the clumps of oysters. Frequently also the oysters are all dredged up and distributed on some other ground, more favorable for their final development. Oyster culture, as it is carried out today, is as complex a matter and requires as much expert knowledge as the cultivation of the land. From the first securing of the seed to the final harvesting of the crop, the processes are always under watchful control and careful supervision.

The oyster, especially when young, has many natural enemies besides man. "Drum-heads" crush the shell, boring shell-fish perforate it, and the beautiful but parasitic star-fish slowly but irresistibly draws it open to feast upon its juicy body. Certain sponges have the power of dissolving the shell, and other small growing things live upon it and even within it without doing any apparent harm.

The oyster feeds upon the microscopic life which abounds in the water. Large volumes of water are drawn through the mantel cavity, and the food material is abstracted by a process of straining through fine cilia. These cilia are in constant motion, carrying the collected particles toward the mouth. These feeding habits obviously provide also an excellent mechanism for collecting germs of disease from a polluted water, and transmitting them to the consumer.

The belief that oysters may at times bring about sickness is older than the germ theory itself. It is difficult to interpret the earlier records but there is evidence of unhappy results following the use of oysters that had been kept too long out of water. On the other hand there is some evidence even in the older records that intestinal disorders of bacterial origin have resulted from eating oysters. Perhaps the earliest positive proofs of this belief was given by Professor Conn of Wesleyan University in 1894. Since that time many epidemics of typhoid fever have been traced beyond reasonable doubt to the eating of infected shell-fish. The most recent of these, and one of the most interesting, has just been reported by the United States Department of Agriculture in its Bulletin 156. Seventeen cases of typhoid fever and eighty-three cases of gastroenteritis were traced to oysters served at a banquet at Goshen, N. Y.

These epidemics constitute the evidence against the oyster. A much worse case can be made out against water, and milk, and perhaps some other foods. In the case of milk, there are not only many demonstrated epidemics of typhoid fever, but also of scarlet fever, measles, and many other contagious diseases, to say nothing of the constant menace of tuberculosis. Yet we continue to drink water and milk and to live. The fact is these demonstrated cases of oyster epidemics have in every instance been traced to conditions which are preventable, and for the existence of which some one should be held liable. The Goshen epidemic was shown to have resulted from the eating of oysters taken in the polluted waters of Jamaica Bay, New York City. In 1905 Soper traced a severe epidemic occurring at Lawrence, L. I., to oysters from the same source, and pointed out the polluted character of the Jamaica Bay waters. Again in 1908 the New York State Board of Health in a general investigation of the oyster waters of the state remarked upon the grossly polluted condition of Jamaica Bay. Despite these warnings and the obviously dangerous character of Jamaica Bay waters, which from time to time have been pointed out by various other investigators, it seems to be nobody's business to prohibit the sale of oysters from this source, so we have had this latest epidemic and shall doubtless have others until the lesson be learned.

This is not an isolated instance. The

Figure 1. Young oysters recently attached to an old shell—August 29

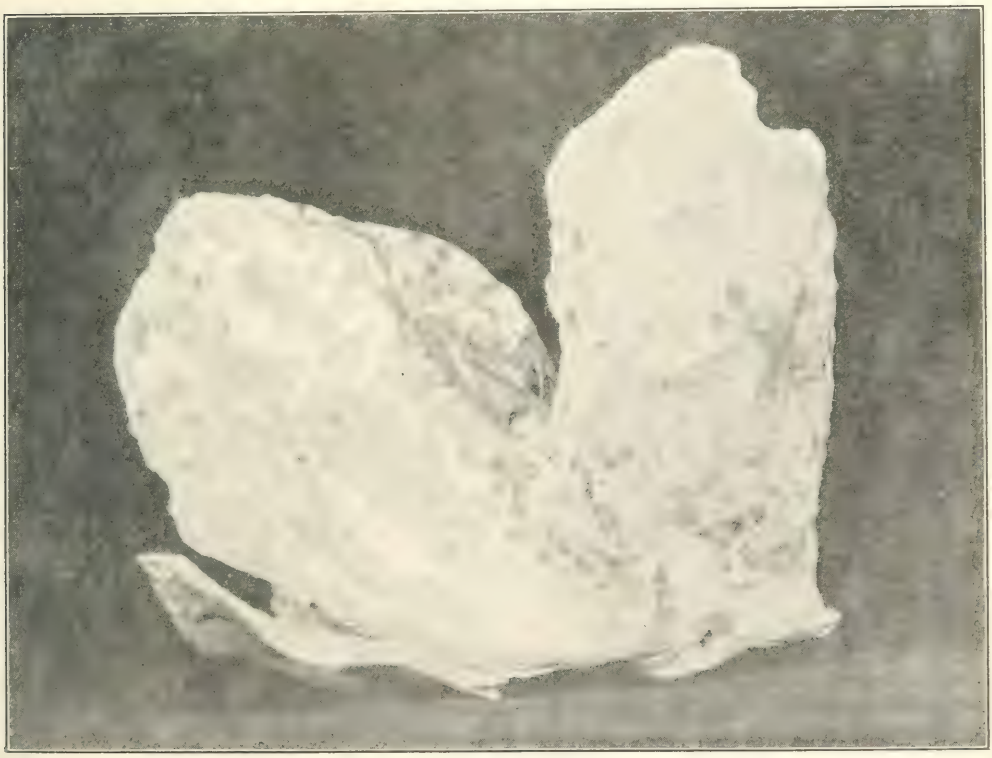


Figure 2. Same "catch" of spat one week later—September 5

Federal Government has pointed out equally undesirable conditions in our own state of Massachusetts, where one of the largest clam areas of the state, if not of New England, is located at the mouth of our most polluted river. This condition, also has been investigated and reported upon by the State Board of Health, and by private interests, but it still exists. The Wesleyan epidemic was traced to oysters which were being fattened in a small creek just below a sewer outlet. Typhoid fever was found in a dwelling connected with that sewer. In every case where typhoid fever has been traceable to shell-fish, like conditions have existed, and it is these rare instances of controllable but uncontrolled conditions that are magnified by those seeking an easy notoriety, until they cover the entire field of vision and obscure all else.

Let us look now at the other side of the question. In most of the states in which the shell-fish industry is an important one, except in New York and Connecticut, important efforts have been made, and are being made, toward the protection of these areas from sewage pollution. In the waters of Chesapeake Bay the total pollution is so insignificant in comparison with the enormous tidal prism of that bay that undesirable conditions are practically impossible. Despite this fact the city of Baltimore has spent millions of dollars for safe sewerage, principally for the benefit of the oyster industry. In New Jersey the activities of the State Board of Health have been devoted to the oyster problem for a number of years, with the result that efficient sewage disposal works are ordered or have been placed at practically all points where sewage discharge might threaten an oyster area. In Rhode Island the State Shell-Fish Commission is charged with the duty of seeing that no polluting matter shall be placed in any of the waters of the state where it can reach shell-fish areas. The commission is at present actively engaged in bringing about the enforcement of this law. The sewage of Providence, constituting 75 per cent. of the possible pollution of the Bay from Rhode Island sources, is being effectively disinfected. Unfortunately Rhode Island has no jurisdiction over the city of Fall River and waters immediately adjacent thereto, save to prohibit the taking of oysters in Rhode Island waters that show evidence of pollution. But this last is being done, for all the oyster beds of the state are annually examined and the taking of oysters from uncertified beds is prohibited by law. Massachusetts is not an important oyster state, its principal shell-fish industry being clams.

In addition to these state enterprises, private interests in many cases are doing even more. Expert bacteriologists carefully inspect and test the beds, control the operations of the opening houses, and in many cases regularly analyze the product as it reaches the market. In this way many of the more advanced dealers, realizing the responsibility which rests upon them, are providing virtual guarantees of the character of their product. It is the duty of the consumer to demand these guarantees. This work of safeguarding the health by conservation of food is going on quietly, without advertising, and the public hears little of it.

But by a peculiar perverseness of human nature this side of the subject is deemed an unpopular cause in which to labor. He who would court popularity must proclaim from the house-tops that all things are vile.

Dr. Harvey W. Wiley, writing in *Good Housekeeping*, has recently announced that all the oysters of New York Bay, Narragansett Bay, Chesapeake Bay, and the Potomac River, the waters near Norfolk, the mouth of the James River, the mouths of the Connecticut and Merrimac Rivers, and other industrial streams, and the continental border of Long Island Sound, are open to suspicion, and should not be eaten raw. In other words, he condemns offhand, more than 75 per cent. of the oysters of the eastern market. It would be interesting to know upon what line of reasoning (if any) this opinion is based. For the evidence one seeks in vain. Doctor Wiley complains that his colleagues have more than once called his attention to the fact that they must have "evidence and not expressions

Figure 3. The same "catch" September 12

Figure 4. On September 20 the oysters have developed to marketable "seed." The old shell will rapidly disintegrate

of opinion." At the risk of offending the doctor let us examine the evidence.

The latest report of the Census Bureau dealing with the fisheries covers the year 1908. In that year there were over 33,000,000 bushels of oysters gathered in the United States. Over 75 per cent. of these came from the sources above enumerated that have come under Doctor Wiley's displeasure. Deducting all others and also those oysters taken for seed, there remain enough oysters to provide every man, woman and child in the United States with six oysters per month during the season. Of course there is no such uniform distribution and the great bulk of these oysters are consumed on the eastern seaboard and in the central states. If then the danger is great, one might at least expect to find evidence in the vital statistics of eastern cities, especially where oysters are consumed in quantity. Providence is such a city. Oysters there are cheap and good and are consumed in large quantities by all classes. Dr. C. V. Chapin, Health Officer of Providence, and one of the highest authorities on sanitary science and vital statistics in the United States, has no hesitation in saying that there is no perceptible amount of typhoid fever in his city coming from oysters. The statistics cover those earlier periods in the history of the oyster industry when conditions were far less satisfactory than at present, and when, in fact, almost no attempt was made to prevent the fouling of oyster beds. This opinion is based upon evidence of a most satisfactory character. It is not only shown that the general typhoid rate in Providence is too low to allow for any material influence from oysters, but that there is no geographical distribution of cases corresponding to the known distribution of oyster consumption in the city. The argument is well based upon statistical data and is conclusive so far as Narragansett Bay oysters are concerned. While statistics of this character are lacking in most other places, one who wishes to inform himself may readily enough learn that Narragansett Bay is not specially favored as regards freedom from pollution. The waters of Chesapeake Bay receive much less pollution in proportion to their bulk, and there are bays and inlets too numerous to mention upon the Atlantic seaboard that are far better protected. In fact the points upon the Atlantic Coast from which oysters ought not to be taken are few and insignificant, and oysters from these sources are generally proscribed by the boards of health. Reference has already been made to Jamaica Bay. The waters surrounding New York City are today unfit for oyster culture, and will probably remain so. There are also some points along the Connecticut shore, especially within the harbors, that are badly polluted, and in many cases there are small local sources of contamination, which ought to be looked after by the local health authorities. But the great bodies of water in which 95 per cent. of the oysters now on the market are grown, are free from dangerous contamination and a similar proportion of the oysters of the eastern market may be safely eaten raw.

Doctor Wiley's opinion of oysters, if it have any single basis of fact, must rest upon an interpretation of bacteriological data upon which he is not qualified to pass, and upon which the courts have thus far been obliged to disagree with him. He has been opposed in this matter, and in most of his "opinions," by leading authorities of the various sciences which he has honored with his attention. These gentlemen, many of them scientists of world-wide reputation, therefore become apostles of "suborned science" and "enemies of pure food."

Who then are the friends of pure food; the popular writer and lecturer, who by a word and upon evidence unacceptable to judge, jury or the leading scientists of the world, condemns and would utterly destroy 75 per cent. of the oyster industry of the United States; or that body of scientific men who are devoting their best thought and energy to the problem of conservation of both health and food? The latter are working quietly and with dignity, seeking not notoriety but only the truth. The history of their labors

Figure 5. Three-year-old oyster. The pencil lines show the growth of first and second summers.

finds no place in the sensational press of the day, but is recorded in the proceedings of the learned societies. Their labors are constructive not destructive, conserving not destroying. They attack disease, not food, and stand as the real guardians of the public health.

A DOUBLE DECK STREET CAR

The street railway companies in the cities of Pittsburgh and New York have recently constructed some double-deck street cars. The use of such cars is quite common abroad, but they have not met with favor in the eyes of street railway managers in this country until recently.

The logic of the situation is that it is impracticable to lengthen the present street cars appreciably, or widen them, and the only means then of increasing the capacity of congested lines is to make the cars higher and in two stories. The success of these cars will depend altogether on the attitude which the public takes toward them. L. E. M.

WIRELESS ELECTRIC CLOCKS

One of the newer inventions in connection with wireless transmission of electricity is that of Mgr. Cerebotani of Munich, who has invented an electric clock similar to the well known Western Union clocks, although it differs from them in being regulated by an electric current sent from a wireless sending apparatus. Such a clock evidently may be set up anywhere and if in tune with a master clock will be regulated by it without any of the expensive wiring which is necessary in the familiar forms of electrically regulated clocks. It is worthy of remark that the new receiving clocks will cost not more than $3. L. E. M.

UTILIZING THE NITROGEN OF THE AIR

IMPORTANT CONTRIBUTION OF THE CHEMIST TO THE PROBLEM OF FEEDING FUTURE GENERATIONS AFTER NATURAL FERTILIZATION OF PLANTS HAS CEASED

BY ARTHUR A. NOYES

A GERMAN geographer has estimated that the world contains seventeen hundred million people, and that they are increasing at the rate of twelve million a year. During each succeeding decade, therefore, provision must be made for feeding a new population greater than the present population of the United States. This demands an enormous, steadily growing increase in the world's output of agricultural products. How to provide for this increase is one of the largest material problems that confronts our generation and the generations to come. Many factors must contribute to its solution. New land must be brought under cultivation by a wider distribution of population, by increased facilities of transportation, by better utilization of the available water supply through storage and irrigation. A larger yield per acre must be secured by improvement of the varieties of food-yielding plants through biological selection and breeding, through the adoption of more economical methods of farming, and especially through increasing and maintaining the fertility of the land by the scientific use of fertilizers in adequate amount.

This last aspect of the problem is the one with which this article is concerned. It is a vital part of the food problem—one which cannot be eliminated by advances in any of the other directions just referred to; for plants cannot live on water and air alone. They consist, to be sure, in largest proportion, of compounds of carbon, hydrogen, and oxygen; and they have the marvelous power of producing these compounds under the influence of sunlight from the carbon dioxide of the air and the water of the soil. But they contain also as essential constituents certain other elements, especially nitrogen, phosphorus, and potassium, which they cannot obtain from the air,—which they must therefore extract from the soil. These elements are, however, present only in small quantity even in virgin soil; and they soon become exhausted through the harvesting of successive crops. It is therefore necessary, in the long run, to return to the soil the quantities of nitrogen, phosphorus, and potassium that are contained in the vegetable products taken from it.

From what sources then can we obtain these three plant foods cheaply and abundantly? This is so large a question that only one of them, nitrogen, will be here considered. Of the three this is by far the most expensive—by far the most difficult to obtain in sufficient quantity at low cost.

Before discussing the present and prospective sources of supply of useful compounds of this element, it should be mentioned that, though the consumption of these compounds in fertilizers exceeds all other uses of them, yet enormous quantities are required in other industries. Thus, the powerful modern explosives which have made practicable great engineering works, like the Panama Canal and the Hudson River Tunnels, are all nitrogen compounds made by the action of nitric acid on glycerin, cotton, or some other material. Most of the so-called coal-tar products, the artificial dyestuffs, drugs, and perfumes, are also prepared from the substances distilled out of the tar by first treating these substances with nitric acid. Ammonia, too, a compound of nitrogen with hydrogen, is used in large quantity in refrigerating machines and in various chemical industries.

Up to a few years ago there were only two important commercial sources of ni-

trogen-compounds, the great natural deposits of sodium nitrate (the so-called Chili saltpeter) in Chili, Peru, and Bolivia; and the crude ammonium sulfate obtained in the manufacture of gas and coke from coal. But the saltpeter deposits will, at the present rate of exploitation, become exhausted within a period variously estimated at from thirty to one hundred years; and in the meantime, owing to increased cost of production, the price of the saltpeter is steadily rising, thus restricting its availability as a fertilizer. The ammonia produced in gas and coke works is only a by-product, and the quantity of it cannot of course be increased beyond that corresponding to the demand for the main products, gas and coke. The total quantity of ammonia thus produced is in fact entirely insufficient to furnish the nitrogen used in fertilizers; and by far the larger proportion of commercial nitrogen is still derived from the saltpeter deposits of South America.

The nitrogen from these sources costs today in American or European markets not far from fifteen cents a pound—a price which is causing a nitrogen famine among the crops of the world; for the cost is too high to admit of spreading it in adequate quantity over the millions of acres of land under cultivation. This condition of things offers a challenge to the scientific investigator; for, though nitrogen is one of the commonest elements, forming, as it does, four fifths of our atmosphere, yet we are drawing nearly all our nitrogen from South American mines or from gas works and are paying fifteen cents a pound to get it in a form available for plant life!

It might seem as if the problem of converting the nitrogen of the air into compounds that can be assimilated by plants was essentially a chemical one; but recent discoveries have opened also to the biologist a great field of investigation in this direction. For it has been found that, although the higher plants cannot utilize directly the nitrogen of the atmosphere, there are certain common kinds of bacteria, which make their homes on the roots of leguminous plants, such as the pea, bean, and clover, which have the power of absorbing nitrogen from the air and of converting it within the roots of the plant into organic nitrogen compounds.

This discovery explains for the first time the fact long known to farmers that the richness of the soil can be increased by rotation of crops—a fact so extraordinary, till its explanation was understood, that one might well have wondered whether it was not one of the fallacious traditions which are so common among farmers and sailors. This increased fertility is now readily accounted for as follows: Suppose that a crop of wheat is first grown on a piece of land, and that thereby the nitrogen compounds in the soil are largely consumed in producing the nitrogen compounds contained in the grain. Suppose now that the next year the same land is planted with clover. As it grows, the bacteria referred to develop upon its roots, absorb nitrogen from the air, and store up in the roots an abundant supply of nitrogenous compounds. After the clover crop is harvested, these roots decay in the soil and yield up to it their nitrogen content, which becomes available for the nourishment of a new wheat crop during the following year.

An interesting illustration of these considerations has been furnished within recent years by the vegetation of the island of Krakatoa. It will be remembered that this island was overwhelmed in the year 1883 by an eruption of its volcano, which destroyed all vegetation and buried the original soil beneath a thick layer of volcanic ashes. It might have been expected that this new soil of ashes, which was of course free from all nitrogenous organic matter, would not be able to support plant life; yet the island soon became covered with an abundant growth. This vegetation was found, however, to be of an unusual character, in that it consisted very largely of leguminous plants, that is, of those plants which, with the aid of bacteria, can take their nitrogen directly from the air.

These facts suggest that the problem

of supplying plants with the nitrogen needed by them may ultimately be solved most simply and directly by the biologist. For through further study of the conditions determining the activities of different species of nitrogen-absorbing bacteria, considered in relation to the kind of crop, the character of the soil, and other agricultural conditions, it may prove practicable, by inoculating the soil with the proper kind of bacteria and by treating it in such ways as will best regulate bacterial growth, to secure all the needed nitrogen from the air. Already, government agricultural stations are furnishing pure cultures of nitrogen-absorbing bacteria which have a limited value in the case of certain soils.

Until such a perfect solution of the problem can be worked out by the biologist, we shall, however, be dependent on nitrogenous fertilizers; and one of the great tasks of the chemist is to cheapen such fertilizers by obtaining the nitrogen contained in them directly from the air. During the last ten years great progress has been made in this direction; and it remains to describe briefly, without entering into technical details, the general lines along which this problem has been successfully attacked.

Two kinds of processes have been developed. One of these has the object of producing nitric acid, a compound of water with one of the oxides of nitrogen. The other kind of process has for its object the production of ammonia, a compound of nitrogen and hydrogen. For use in a fertilizer the nitric acid, which is a liquid, or the ammonia, which is a gas, must of course be converted into a solid salt. This is most cheaply done by neutralizing the nitric acid with lime or the ammonia with sulfuric acid, yielding calcium nitrate or ammonium sulfate, respectively. Whether the nitrate or the ammonium salt is made the constituent of the fertilizer makes little difference; for, though plants directly assimilate the nitrogen only in the form of nitrate, yet there are always present in soils the so-called nitrifying bacteria whose function it is to convert ammonium compounds into nitrates.

Nitric acid is a compound whose constituents, nitrogen, oxygen, and water, are present in unlimited quantities in the air. The raw materials are available free of cost. The problem is, therefore, only how to make them combine under economic conditions. The difficulty arises from the fact that nitrogen is an extremely stable substance; so that, instead of tending to form compounds with oxygen, the nitrogen oxides tend rather to break down into their elements, nitrogen and oxygen. Thus, scientific investigations have shown that if a mixture of these two gases in the best proportions is exposed to a temperature of 1500° centigrade, that is, to a white heat, only one third of 1 per cent. unites to form nitric oxide, however long the mixture be heated. These investigations have also shown that, while most compounds decompose with rise of temperature, this one, nitric oxide, becomes more stable, the higher the temperature. Thus at 3000° 5 per cent. of the mixture of nitrogen and oxygen will unite to form nitric oxide. To get a fair yield of our product we must, therefore, expose air to an enormously high temperature. But this isn't all; for how can we cool off the gas without causing the nitric oxide which has formed to break up again into nitrogen and oxygen? To do this, we must call to our aid another chemical principle, which is this: although the quantity of a product finally formed in a chemical process sometimes increases and sometimes (as in this case) decreases with falling temperature, yet the *rate* at which that product forms or decomposes always decreases very rapidly as the temperature is lowered. We must, therefore, expose the air to a very high temperature and then very suddenly cool it to a temperature so low that the nitrogen oxide already formed does not decompose at an appreciable rate.

These conditions have been practically realized in only one way—by causing an electric discharge, similar to that in an ordinary arc-lamp, to take place in air. The temperature of the arc is enormously high, but the air just outside of it is comparatively cool; so that any nitrogen

oxide formed at the boundaries of the arc mixes at once with the colder air and thus escapes decomposition. The excess of air containing the oxides of nitrogen is then passed into towers filled with quartz over which water is trickling, whereby nitric acid is formed.

It is not necessary to enter further into details; for these are the essential features of the commercial process for the manufacture of nitric acid which is now being carried out on a large scale at Notodden in Norway. Aside from the cost of installing and maintaining the electrical and absorbing apparatus, the only large expense involved in the process is the cost of power used in producing the electrical discharge. The works must, therefore, be located where water power is obtainable at the lowest possible cost; and Norway was naturally chosen as the seat of the industry in Europe. The saltpeter factories there are already utilizing 200,000 horse-power; and thousands of tons of their product have been shipped to this country, for use in fertilizing the fruit orchards of California and the sugar plantations of Hawaii.

Almost simultaneously with this process for the manufacture of nitrate there is being developed a process for the artificial production of ammonia, its competitor in the fertilizer field. The aim is to produce this compound also from its elementary constituents, nitrogen and hydrogen. Nearly pure nitrogen can now be obtained cheaply from the air by a commercial process which up to twenty years ago had been carried out only on the smallest laboratory scale; namely, by liquefying air with the aid of a liquid-air machine, and then distilling the mixture of nitrogen and oxygen, much as a mixture of alcohol and water is distilled in the rectification of spirit. The nitrogen, having a much lower boiling point, passes off first, yielding a gas containing less than $\frac{1}{2}$ per cent. of oxygen, which can readily be removed from it by chemical means. Pure hydrogen can be obtained cheaply by the decomposition of water in two or three different ways. The raw materials needed for the production of ammonia, although not costless like the air and water used in making nitric acid, are therefore obtainable at low cost; and the main problem again consists in finding a practical way of causing them to combine.

It is a curious fact that difficulties are met with here which are just the reverse of those encountered in the synthesis of nitric acid. Ammonia is a compound on which temperature has the opposite effect: instead of forming in larger proportion as the temperature is raised, it forms in smaller proportion; thus, if a mixture of nitrogen and hydrogen be heated for a long time to 800° centigrade, only one hundredth of one per cent. of ammonia forms, while it can be calculated that at 400° one half of one per cent. of ammonia must finally result. We ought, therefore, to work at as low a temperature as possible; but we then meet the difficulty that the rate of combination becomes extremely slow. Thus, owing to the extreme inertness of nitrogen, no detectable quantity of ammonia is produced, even when nitrogen and hydrogen are heated together for several hours at 400°. When, however, it is known that a chemical change tends to take place in a certain direction and when the only difficulty is that it is going on too slowly, there is always a reasonable hope of overcoming this difficulty; for we know that chemical changes are often greatly accelerated by mere contact with solid substances. Such substances are called catalyzers, and Professor Wilhelm Ostwald, one of Germany's distinguished scientists, predicted a dozen years ago that the great advances in the chemical industries within the next few decades would be made through the more extensive employment of catalytic processes. This prediction has found one of its many fulfilments in the commercial development of the method for the production of ammonia here under consideration. For after many years' investigation certain metals have been found which cause a rapid combination of nitrogen and hydrogen even at comparatively low temperatures. The first metal that was found to have this power in a marked degree was osmium, a metal similar to platinum. As

the total quantity of this element in our possession is estimated to be 200 pounds, and as it is valued at $1,000 a pound, this discovery was hardly a practical one. Later it was found, however, that under special conditions some of the commoner metals, such as uranium, manganese, and even iron, when extremely pure, can be made to serve the purpose. Without entering into further detail, it may be stated that a satisfactory yield of ammonia can be attained by carefully purifying the hydrogen and nitrogen gases, by highly compressing them (up to 50 or 100 atmospheres) and then passing the compressed gases slowly over one of these metals at 500°–600°; and that a large factory for the manufacture of ammonia by this process is now being erected in Germany.

Certain other chemical processes for the fixation of atmospheric nitrogen, less direct than those already described but nevertheless commercially practicable, have also been developed and put into operation within the past ten years. There is, therefore, little doubt that from these sources a large and additional supply of nitrogen compounds will soon be available and that their cost will be gradually lowered. To the vital problem of feeding the human race the chemist is, therefore, making an important contribution.

SWISS AERIAL RAILWAYS

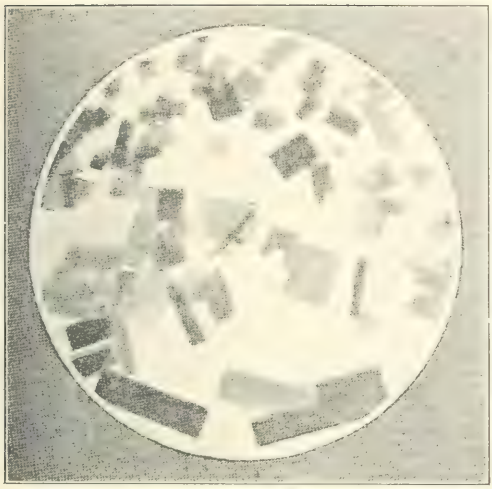
The first aerial railway projected in Switzerland was the work of a German engineer in 1901. The concession was secured in 1904, a company organized, and in 1908 a portion of the road was inaugurated. In the first section the two extremities of the line are separated by a horizontal distance of 1,000 feet, the average incline for the course being 45°.

The line passes over the Grand Glacier that descends the Wetterhorn and at considerable distance from the rocky, precipitous sides of the mountain, nearly to the summit. It is in operation from June 1 to October 1 only, as the heavy snows in the mountains during winter make transportation impracticable and dangerous. The popularity of the Wetterhorn route is handicapped by the fact that the starting point is several miles from Grindelwald, the principal town in the valley, which has no railway connection. Statistics show that 3,000 passengers were carried over the road in 1909, 3,600 in 1910, and 5,000 in 1911.

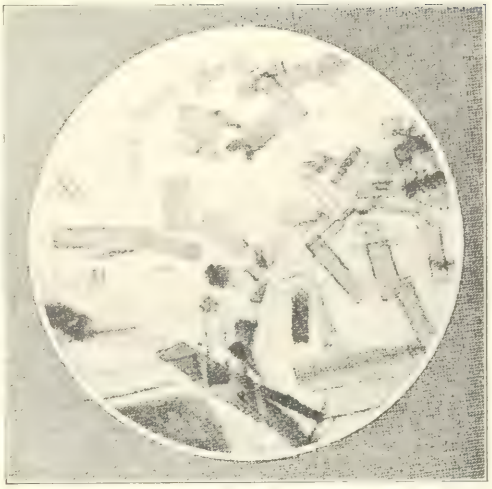
Since the introduction of cable, rack and pinion, and aerial railways in Switzerland, attention of engineers has been directed toward Mount Blanc, the highest peak in Europe and most famous in the Alpine ranges, with the beautiful valley of the Chamonix leading up to its base. On both French and Swiss sides Mount Blanc is comparatively easy of ascent toward the base and not especially abrupt even in the higher regions thus simplifying the problem.

A rack and pinion road has been built and is now in operation from the Valley of Fayet and Chamonix well up on the side of the mountain. From Fayet it ascends to St. Gervais, from where, by an incline road on a grade of 16°, it reaches the Col de Voza at an altitude of 5,500 feet. This road, which is to be supplemented with an aerial line similar to that on the Wetterhorn, is to be extended to Tate Rousse and from there around the sides of the Aiguille de Gouter, from which, through tunnels and galleries, splendid views of the glaciers will be afforded.

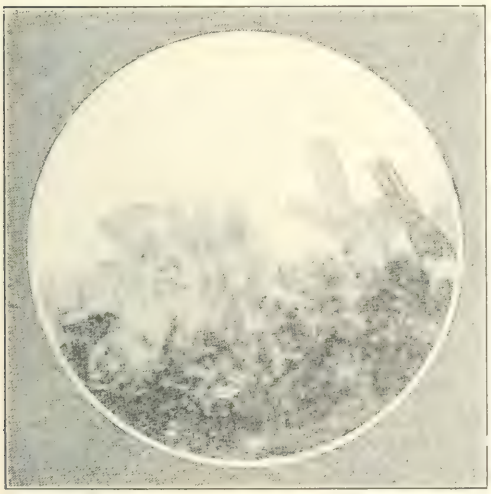
The aerial route will start from the town of Chamonix, at an altitude of 3,000 feet, and will ascend to the Glacier des Bossons at 7,500 feet with two intervening stations. The grade on this section will be 50° to 60°, and the line will finally be extended to the Aiguille du Midi at an altitude of 11,500 feet. The first section is to be completed in 1913 and the extension completed the following year. This road will be worked with three cables—the carrier, the tracteur, and one for the brakes. The carriages will accommodate 24 persons each and are to be supplied with automatic brakes and provided with every possible device for insuring the safety of the passengers.



Blood-Crystals of a Baboon



Blood-Crystals of an Orang-Outang



Blood-Crystals of a Chimpanzee

Blood-Crystals of a Man

HOW BLOOD CRYSTALS DIFFER

Those who are not directly connected with microscopie work have, doubtless, often wondered how the human blood can be distinguished microscopically from the blood of simians, or other animals. A new and more delicate test than any heretofore devised has been worked out by two members of the faculty of the University of Pennsylvania. Their test consists in causing the red coloring matter of the blood to form crystals under certain circumstances. These crystals are examined microscopically. By this examination it is possible to tell the difference between not only human and simian blood, but between white and negro. The illustrations show typical blood crystals from the sources indicated.

L. E. M.

WHAT THE ATMOSPHERE IS MADE OF

SIR WILLIAM RAMSAY IN LOWELL INSTITUTE LECTURES GIVES INTIMATE HISTORY OF THE DISCOVERY OF THE GASEOUS COMPONENTS OF AIR

BY JOHN RITCHIE, JR.

If the Lowell Institute lectures on the gases of the atmosphere, by Sir William Ramsay had done nothing more than show to the American public the simple and sterling character of the man and the extraordinary wealth of resource in expedient at his command, they would have been well worth the giving. But they did much more, for besides the academic story of discoveries that have made their mark upon the chemical world, there was the constant running fire of comment by one intimate with every detail in the long and complicated processes. How interesting, for example, in the naming of neon, to learn that it was the young son of Sir William, home on a vacation from school, who strolling into the laboratory learned of the discovery of the gas. "And is it truly new?" he queried, and on being assured that it was, he said, "Why not call it Novum?" The Latin terminology was, however, not of the customary order, so the Greek was called into requisition and "Neon" it became.

The lecturer took to his country most of the credit for discoveries with reference to the atmosphere, noting that Britain is proverbially ruler of the seas; that she, in the opinion of many is acquiring too great dominion over the land and in the third element, air, "all but one of the important [chemical] discoveries were made by Englishmen."

In his introductory lecture Sir William gave a short history of the chemistry of air and displayed in it some of his philological lore, telling his hearers that gas and ghost are kindred words, gust being another relative, indicative of the fancied relations between air and the spirit or life. "Gas is a made word," said the lecturer, "and is common to modern languages, while another such manufacture, 'blast' was coined in expression of the life of the stars. But since stars have no life from man's point of view, it has not come into familiar use."

The historical story was a very interesting one, pivoting on the old "phlogiston," which became a catch-all for the explanation of obscure phenomena. Phlogiston was that which substances lost in various processes of burning. The scum of melted lead—now known to be lead oxide—was made by phlogiston and if removed the lead was dephlogisticated. Air might likewise be dephlogisticated, and as this material was added or removed the intricate phenomena resulted.

The four elements of the ancients, fire, water, earth and air, with contrasted qualities, individually and in pairs, persisted till the fifteenth or sixteenth centuries. Earth was cold and dry; air, hot and moist; water, cold and wet, and fire, hot and dry. Boyle in the early sixteen hundreds; Mayow, born during the life of Boyle, but quiet and practically unnoticed and Stephen Hales, worked each diligently as chemists, considering all gases to be air and having no other notion. Mayow found out that air has "nitro-aëreal particles" and "mephitic," and Hales discovered that a great deal of gas can be derived from small quantities of solids. He distilled many things in his laboratory, including what are modern products; he saw that air is a chaos of elastic and inelastic things, but he failed to catch the import of his discoveries. Thus far everything had been hypothetical, there was no standard used and phlogiston was ready at every turn to account for strange results.

Joseph Black was the first real discoverer; he brought into requisition delicate scales, and came upon the idea of

changed chemical condition later developed into "conservation of matter." An experiment with magnesia was repeated by the lecturer in much the same form as worked by Black, in which after decomposition, the magnesia was reconstructed. Black's pupil, Rutherford, born in 1749, took for his thesis the qualities of a cold, fixed air, which was really an investigation into the nature of the residual gases after certain kinds of experiment.

It was Priestly, born in 1733, who discovered oxygen, and he had such confidence in its life-giving qualities that he inhaled it, looking forward to the time when others might avail themselves of the luxury, "which till now has been enjoyed only by two mice and myself." Then came Lavoisier, who first mentions nitrogen under the name it still has with the French, azote, he determining that there are four kinds of air, common air, pure air, which is indeed oxygen, azotic gas and fixed air, which is carbonic acid gas. He had really the mystery of the air within his grasp, and produced hydrogen from water, but in the very last of his many memoirs defended phlogiston.

The general historical story ended with Cavendish, quiet and retiring, almost unknown save in very limited circles, who discovered the composition of water. He maintained the idea of phlogiston although the lecturer showed that he did so from the desire to speak to his contemporaries in current phraseology rather than on account of belief in it. He did question to himself the validity of this curious substance and, had he used the chemical balance in his experiments, would undoubtedly have discarded it altogether. He plainly states that where there is phlogiston there is always water and suggests that it may be the water that is effective. He worked largely for his own pleasure and was not quick to make public his discoveries. He did accomplish, however, most remarkable things, some of them in other fields. He accumulated facts which were accurate quantitatively; for example, that there is 1–120 of the air that will not combiñe, a figure that today, one hundred and thirty-five years later, is set at 1–84. He computed the density of the earth arriving at the figure, 5.4 with water for the standard, and more than a century of observation, measurement and computation has changed only the decimal places, the accepted constant being now 5.5777.

The work that this man did was wonderful whether taken in quantity or quality. He worked a great deal with the air, he analyzed it for sixty days and in many places, he showed its constant composition and really paved the way for the discovery of argon. One series of experiments was made to find out when a quantity of air was diminished by phlogistication, where the missing air went to.

How argon came to be discovered was one of the most charming of the series of lectures for here Sir William Ramsay spoke of his relations with Lord Rayleigh and drew a pen picture of this distinguished and broad minded investigator, whose experiments in determining the relative weights of oxygen and hydrogen led first to publications from 1882 till 1893, the last year seeing a comparison between oxygen and nitrogen; next to the request to the members of the Royal Academy for suggestions, and last, to a meeting with Ramsay. Rayleigh had been working out the comparative densities of the gases and to check his observations he made use of gas produced in a number of different ways. He had oxygen from three different sources and found an agreement in the weights between them, but nitrogen when derived from ammonia he found to be lighter than when taken from the atmosphere.

At this juncture Ramsay suggested to Lord Rayleigh that the repetition of some of Cavendish's old experiments might give a clue to the mystery, and Rayleigh said, "Try it out yourself." The experiments, which were repeated on the platform, developed a method of consuming the nitrogen from ordinary air. The oxygen was first removed, then any traces of water and then again a trap was laid for any remaining oxygen. The nitrogen that was left was forced through chips of magnesium and was more or less consumed. At first there was a simple device for

returning the nitrogen again and again to the magnesium and later automatic methods were devised which would effect this end till it was consumed. Means of testing were always possible and the speaker showed how in the successive devices there were improvements. It was evident after a while that there was an unconsumed residue, and this was argon.

Incidentally the lecturer told that he had taken magnesium for the selective material from the fact that in the old experiment when it was burned in a close crucible there was the odor of ammonia showing combination with the nitrogen of the air. In the later experiments, a mixture of lime and magnesium has been substituted for the magnesium chips. He noted that when the experiments were under way the announcement of the offering of the prize from the Hodgkins fund in the possession of the Smithsonian Institution was made. He spoke of this to Lord Rayleigh, suggesting to him to try for it, but the latter would do nothing by himself and made Ramsay take common cause with him.

In August, 1894, the announcement of the discovery of the new gas was made to the British Association. Sir Oliver Lodge was present and said, "These young men have discovered something that is new; have they also discovered its name?" A name was therefore sought, and since the gas was inert, the text, "Why stand ye here all the day idle?" was suggested. Argon is the neuter of the Greek word, idle, in this phrase.

The argon story of Sir William Ramsay, quietly and modestly told, was a key to the supreme scientific character of this leader in chemistry, for it showed his resources as well as his patient care and industry in trying thousands of experiments and one could see the acute inventive mind working all the time to evolve new processes or simplify and perfect those already known.

One fact that puzzled the discoverers of argon was the fact that its spectrum was subject to variations, and these were so curious that it was suggested that here might be a triad of gases and the names, Anglium, Scotium and Hibernium were even suggested for them. But the investigators worked on trying for results instead of anticipating them by processes of guessing. How to get more argon, how best to produce it and with what substances would it combine were the lines of research. First of all, typical animal and vegetable sources were tested to see, of course, whether some substance richer in argon than the atmosphere could be found. Mineral waters were also tried and it was finally concluded that argon is a component not of the atmosphere alone but is contained in various earthy products.

With reference to the combination of argon with other substances, the possible range was carefully tried out. The speaker named a score of active agents to which it was inert, the line was passed where gold is no longer resistant to change and then the limit for platinum. Argon was not affected by electric sparking nor by fluorine, which is of great activity in making combinations. Then the fierce energy of the electric arc was tried and at the other end of the thermal scale, liquid air. From all of these tests argon emerged unchanged and undiminished and the distinguished lecturer said, in concluding this part of his series of topics, "It may be possible to make a combination with argon, but in the light of knowledge today it is difficult to see how it can be done." The making of argon was one of the experiments of the evening of this lecture.

The story of helium was begun by Sir William at a number of different points. First there was related an outline of what was done by Doctor Hillebrand of the United States Geological Survey, who in heating some of the compounds of uranium—a rare element—found a gas whose spectrum was unknown to him. Janssen, the great French astronomer, during the solar eclipse in India, obtained with the comparatively new spectroscope a spectrum having a bright yellow line. The great English spectroscopists tried to place this and finally the world came to the realization that it was a new gas and it was named helium. Sir William Ramsay secured from Doctor Hillebrand some

specimens of his mineral, cleveite, for experiment and soon saw that the spectrum was not that of sodium which also has a bright yellow line. Taking it to Sir William Crookes, who was better fitted out with spectroscopic apparatus, the latter viewed the spectrum and pronounced it to be that of helium, then first identified from earthly materials. The next thing, of course, was to find out by what it could be produced in larger quantities. "The proverbial needle in the haymow was simplicity itself," said the lecturer, "compared with this task," and the outlining of what was done in the research is testimony to the splendid resources of the great Englishman, or rather Scotchman. The British Museum was ransacked for minerals and about two hundred likely samples were taken. These were subjected to tests, but no new spectrum resulted; then the gases of mineral waters were tried and even the volcanic gases of Iceland, to which country Sir William journeyed on his quest. Meteorites were heated and a great range of such experiments tried, but all without avail. "And all this time," said the lecturer, "it was all about us in the commonest thing we had, the air." This was in 1896 and the means which were to put the great results into the hands of the investigators were just coming into reach of scientific men. This was liquid air, and by way of return for courtesies of the laboratory the first litre of this product made by an Englishman in a new way was sent to Sir William. The relation of this to the discovery was that cocoanut charcoal has an extraordinary appetite for gas and the colder it becomes the more gas it will absorb. Charcoal chilled to the very low figure of the temperature of liquid air does select from mixtures of gases in contact with it all of those then known to be in the air excepting helium. This gas was not absorbed in such processes and the scientists collected it in sufficient quantity for the determination of its various chemical constants.

Gaps in the rhythmic order of qualities as shown by the tabulations of chemical elements furnished the suggestion that there were missing elements and the low temperatures of liquid air and hydrogen furnished a means of separating them from their companions. In a rough way the process may be explained by the different temperatures at which the different gases liquefy or freeze. One gas will become liquid while another is still a gas, or freeze while its companion is a liquid. The gas can be pumped out or the liquid drawn off, while the second gas remains in different condition.

The litre of liquid air that was received by Sir William was used largely for amusement, the scientists literally playing with the strange, new material. When it was nearly all gone, scientific tests were suggested and the familiar treatments were given it. It was found that the residue had a higher weight than the normal one of argon. From this circumstance there came the separation of krypton, so called because it had been hidden.

Of course with the increasing ease with which liquid air could be obtained such experiments were repeated and it was noticed that even with the krypton taken out, there was always a bubble of residue. This was tested in the ways known to chemists; the spectrum showed that it was still a different gas and xenon, the stranger, was produced. It was the separation of the gases by means of their different vaporizing points that was now used in the discoveries. Xenon proved to be the heaviest gas then known, sixty-six times the weight of hydrogen.

At this time, in 1898, the business of liquefying air assumed relatively great magnitude, and the investigators in London were able to acquire a considerable quantity—fifteen litres— of argon. This was treated in the various ways that had been evolved in previous experiments and from it was produced or rather separated a light gas with red spectrum. This was neon. Still more recently through the ability to get larger quantities of argon, it has been possible to gather as much as 120 cubic centimetres of neon. This has been tested in all the ways known to chemistry of today to determine whether still other gases are in combination with it, but it has resisted separation so that

the discussion in this direction seems to be finished.

Although it would seem as if here would be the end of the story of gases in the atmosphere, the final lecture brought out the fact that still another remained, which in due sequence of investigation and discoveries, was found and its characters determined. This was niton, so-called because when frozen it shines. The story was one that took up the investigations in the matter of radio-activity. It is known that electricity may be gathered high in the air and its source was always a mystery. It is now known that it is formed by the decomposition of the gases. The radio-activity story led up to the showing that there is a radium emanation which has certain peculiarities and relationships in a curious group of activities. This is now known to be a gas and a constituent of air. Its presence was suspected at last through a gap in the chemical tabulation of elements. Hydrogen was suspected of being possibly in combination with something; the temperature of the combination was lowered; there was a process of solidification at a temperature at which hydrogen was still unfrozen, the latter was pumped out and the residue examined. Thus the gas niton was found, an unstable one, it would seem, for the members of the radium group of substances are continually parting with atoms or electrons and becoming other members of the group. Helium and electrons are alternates in this loss, which is a phenomenon giving rise to new concepts in chemistry.

MECHANICAL CANAL LIFTS

On the branch canal connecting the Brussell-Charleroi route with the Canal du Centre between Seneffe and Houdeng in Belgium, there is a difference in elevation of about two hundred ninety-five feet in fifteen miles with the further complication of a lack of water supply in the upper reaches. It has become necessary to use four mechanical lifts which together accomplish a rise of two hundred eighteen feet, each lift overcoming from fifty to fifty-six feet difference in elevation. These lifts consist of pairs of steel chambers, nineteen by one hundred forty feet and ten feet deep, supported on hydraulic plungers. The two chambers of a lift move in opposite directions, simultaneously raising and lowering a 360-ton barge on the two sides.

EROSION BY RAINFALL

The United States Geological Survey is responsible for the statement that the surface of the United States is being removed at a rate of thirteen ten-thousandths of an inch a year or one inch in seven hundred and sixty years. This means that two hundred and seventy million tons of dissolved matter and five hundred and thirteen million tons of suspended matter are transported to tide water every year by the streams of the United States.

This total of 783,000,000 tons represents more than 350,000,000 cubic yards of rock substance, or 610,000,000 cubic yards of surface soil. If this erosive action had been concentrated upon the Isthmus of Panama at the time of American occupation, it would have excavated the prism for an 85-foot level canal in about 73 days. The amounts removed from different drainage basins show interesting comparisons. In respect to dissolved matter, the southern Pacific basin heads the list with 177 tons per square mile per year, the northern Atlantic basin being next with 130 tons. The rate for the Hudson Bay basin, 28 tons, is lowest; that for the Colorado and western Gulf of Mexico basins is somewhat higher. The denudation estimates for the southern Atlantic basin correspond very closely to those for the entire United States. The amounts are generally lowest for streams in the arid and semiarid regions, because large areas there contribute little or nothing to the run-off. The southern Pacific basin is an important exception to this general rule, presumably because of the extensive practise of irrigation in that area. The amounts are highest in regions of high rainfall.

PROGRESS IN A PUZZLING MALADY

HOW THE STABLE FLY HAS PROBABLY BEEN RELATED TO INFANTILE PARALYSIS—STORY OF AN INTERESTING RESEARCH IN MASSACHUSETTS

BY CHARLES T. BRUES

THE fact that several common human diseases are spread through the agency of blood-sucking insects is now quite familiar to the general public, in spite of the very short space of time which has elapsed since any disease was shown to be specifically insect-borne.

Nevertheless it is difficult to realize that scarcely more than a decade separates the present from the time when yellow fever and malaria were removed from the category of mysterious maladies whose method of spread was utterly unknown. These, together with splenetic or "Texas" fever of cattle formed a nucleus about which has been grouped a number of other human and animal diseases all of which are transmitted by specific insects or closely related animals. Certain mosquitoes, blood-sucking flies, ticks, lice and bugs have thus been shown to be concerned in the spread of disease and their pernicious activities have been carefully investigated from the standpoint of public health.

The most recent addition to the category of insect-borne diseases is anterior poliomyelitis or acute epidemic poliomyelitis, more commonly known as infantile paralysis.

Stable Fly (Stomoxys Calcitrans) loaned by Dr. Sheppard for Photographic Reproduction

During the past several years a suspicion has been developing among students of this disease that it, too, might result from infection carried by some insect, and the Massachusetts State Board of Health decided to have this possibility investigated during the summer of 1911, under the direction of Dr. Mark W. Richardson, the secretary of the board. Accordingly, as entomologist, the present writer in company with Dr. Philip A. E. Sheppard, who was investigating for the State health authorities the epidemiology of the disease, attempted to determine by observation in the field, whether any special insects might appear to be associated with the cases which occurred that season in eastern Massachusetts. Working in this way, it was possible to eliminate many insects which might otherwise have been suspected as carriers, and as the season's work progressed the suspicion gradually

grew more and more strong that the common stable fly (*Stomoxys calcitrans*) might be the insect concerned, especially as the seasonal history, distribution and habits of this blood-sucking fly appeared to fit in closely with the observed epidemiology of the disease.[1]

During the past summer of 1912 Prof. M. J. Rosenau of the Harvard Medical School, who was already thoroughly familiar with the disease, and the present writer, undertook to determine experimentally with monkeys, whether the stable fly could act as a vector for the virus of poliomyelitis. The successful outcome of this work has very recently been announced in a paper [2] describing the experiments in which healthy monkeys developed poliomyelitis after having been bitten by stable flies which had previously fed upon the blood of monkeys infected with the disease. These results have been further confirmed by Drs. Anderson and Frost of the Public Health and Marine Hospital Service,[3] who repeated the same experiments and definitely proved that the disease develops in monkeys which have been bitten by stable flies that have previously fed on monkeys suffering from poliomyelitis.

The stable fly is a small insect very much like the ordinary house fly, to which it is closely related, and for which it is frequently mistaken on account of its size, rather similar coloration and common occurrence in the neighborhood of human habitations. In spite of its close similarity to the house fly, it differs in a number of important respects, both in structure, habits and distribution, and on account of its recently discovered relation to human welfare, it is worth while to mention these briefly.

The adult flies feed exclusively on blood, biting various animals and less commonly, but nevertheless quite frequently, biting persons upon parts of the body where the skin is exposed, or where the clothing is thin. Among domestic animals they occur most commonly on cattle and horses which are often much annoyed by them during the later part of the summer. On account of their feeding habits, the flies are more common in rural districts where the number of animals is large, or in the case of more thickly populated districts, in the neighborhood of stables or places where large domestic animals are most numerous. It is difficult, however, to find any locality of any considerable extent under ordinary conditions where this fly does not occur. Although the flies are found in the vicinity of dwellings, they do not enter homes so commonly as does the ordinary house fly, but rather prefer to remain in the open and more especially in sunny places unless attracted elsewhere by animals or persons. Their normal food consists of mammalian blood and during its lifetime each fly feeds every two or three days, perhaps oftener, upon some warm-blooded animal, less commonly biting human beings. In fact this insect has given rise to the adage that house flies bite before a rain, which is based on the fact that persons are frequently bitten at such times by Stomoxys, which are then apt to come indoors and are mistaken for the house fly. The latter cannot pierce the skin, however, with its soft, blunt mouthparts, while Stomoxys can readily insert its needle-like proboscis into the flesh. In the writer's experience, however, Stomoxys seems to have more commonly bitten on warm, bright days, although he has been bitten even at night while writing near an electric light. Other observers have noticed that the flies often seek shelter at night. Both sexes are blood-suckers, and become greatly swollen when allowed to feed unmolested.

[1] Brues, C. T., and P. A. E. Sheppard. The Possible Etiological Relation of Certain Biting Insects to the Spread of Acute Epidemic Poliomyelitis. Bull. Mass. St. Bd. Health, December, 1911, pp. 46–48 (abstract); Journ. Econ. Entomology, Vol. 5, pp. 305–324, August, 1912 (full report).

[2] Rosenau, M. J., and C. T. Brues. Some Experimental Observations upon Monkeys Concerning the Transmission of Poliomyelitis through the Agency of *Stomoxys calcitrans*. Bull. Mass. St. Bd. Health, Sept., 1912, pp. 314–317.

[3] Anderson, J. F. and W. H. Frost. Transmission of Poliomyelitis by Means of the Stable Fly (*Stomoxys calcitrans*). Public Health Reports, Vol. 27, No. 43, pp. 1733–1735 (October 25, 1912).

When thus engorged they remain sluggish for a time and are apt to rest with the wings somewhat more widely spread apart than the house fly, and with the body more distinctly elevated, assuming a more sprightly attitude.

If one of the flies is examined closely from above as it rests thus, the proboscis can be seen projecting horizontally like the tip of a fine black pin directly forward from the lower edge of the head. Viewed from the side, the proboscis is seen to emerge from the lower side of the head and then bend forward at right angles for a distance about the height of the head. When sucking blood, the proboscis is straightened so that it projects directly downward from its attachment to the head. In the resting house fly the mouthparts never project forward so as to be visible from above, and this difference will always serve to distinguish the two species at a glance.

Stomoxys appears early in the spring, but becomes much more abundant after midsummer and persists in numbers late into the fall, after the house fly has begun rapidly to disappear.

The breeding habits are much like those of the house fly. The eggs are deposited in small masses; the individual eggs are long, slender, minute objects of a pearly white color. Each hatches into a minute white maggot, slender at the head and enlarging behind to a blunt posterior end. The maggot or larva feeds rapidly, increasing in size and molting twice before changing into the pupa or resting stage from which the adult fly will emerge four or five weeks after the egg has been laid. The pupa is enclosed in an oval brown shell or puparium which is broken open at the head end to afford an exit for the emerging adult fly at the termination of the pupal stage.

The eggs are laid directly upon the materials which will serve as food for the larva. Fermenting heaps of grass, straw and similar substances, horse manure cow dung and even garbage may serve as breeding places. The relative importance of these different foods is not yet very well known, but it seems probable that this is about in the order named. Excessive moisture is also particularly favorable for the development of the larvae.

Stomoxys calcitrans is very widely distributed over the earth, occurring abundantly throughout Europe, North and South America, the West Indies, northern Africa, Asia, Australia, etc. It is the only member of its genus in the New World, but has a number of close relatives in the tropics of the eastern hemisphere. Whether it is native to North America or is an importation from the Old World is difficult to say, but from its wide occurrence, one would be perhaps inclined to think it native to our own region. At any rate it has been in America for a long period.

The control of *Stomoxys* will probably prove as difficult as that of the house fly and its eradication is obviously impossible. The ordinary flytraps and sticky flypapers which have proved so useful in dealing with the house fly are of no practical benefit in combating *Stomoxys* since it is not attracted to the resinous coating of the paper nor to the baits used in fly traps; as its only food in the adult condition is the blood of living animals, it is attracted only to such and cannot therefore be caught in traps. However, the "coming and going" flytraps devised by Professor Hodge will undoubtedly catch large numbers of *Stomoxys* if attached to the doors and windows of stables and barns. The most important method of control must undoubtedly depend upon the fact that the species develops in manure, decaying grass cuttings, etc. The proper handling of these is a difficult matter but can unquestionably be solved and will aid materially in abating the house fly nuisance as well.

Editorial Note:—It is interesting to note the origin of Brues-Sheppard hypothesis of transmission by fly bites. During his investigations of 1910 and early in 1911 Doctor Sheppard had been repeatedly told of fly bites in the history of the cases of infantile paralysis. It was only when Mr. Brues, a skilled entomologist, was selected to work with him in

the matter that the particular fly was found. The two men found together in Southboro in August, 1911, that in a family of six children and two adults, all the children were affected, one having been affected also sixteen years before. Two deaths occurred there. The types of disease varied from a slight involvement of the muscle to a fatal paralysis.

Stomoxys was found in great numbers about the barn, on the cattle and about the house distant one hundred yards from the barn. It was even in the chambers of the house where the sick members of the family were lying. Doctor Sheppard noticed that the flies in the latter room were filled with blood, presumably taken from the human cases.

The conclusion was reached that there is good reason to suppose that mature Stomoxys will carry the organism from one human sick person to another individual by means of its bite. This was the basis of the experiments. It is still to be shown, however, whether this transmission is merely mechanical or that a definite period of incubation is necessary in the fly before it can give the infection; whether the fly can give infection at once on biting some other person, or whether definite time must ensue before Stomoxys is able to infect.

There will be some further question in the matter as to persistence of the virus in recovered humans. In the Southboro family the girl of nineteen years, who had an attack long before, was upset by some gastro-intestinal difficulty. There is here the question whether with her balance upset she may not have been the origin of the other infections in the family.

PROTECTING PANAMA CANAL GATES

A RECENT article in *The Engineering Record* describes many accidents which have happened to canal lock gates, both here and in Europe, due to a variety of causes which have been taken into consideration by the engineers of the Panama Canal. By way of precaution the following safeguards will be employed:—

Vessels will not be allowed to approach the locks under their own steam, but will be towed through long approaches at both ends and through the locks by one or more locomotives on each side of the canal. Other locomotives in the rear will keep the vessels under balanced control. At each end of the locks will be a pair of guard gates, exact duplicates of the operating gates and 60 or 80 ft. distant from them. Finally the gates will be protected by an exterior barrier consisting of a horizontal transverse chain with a breaking strength of about 250 tons. The ends of the chains will be attached to the plungers of hydraulic cylinders so that the chains will operate as automatic buffers to receive the impact of a vessel, which, as it presses against the chain, gradually develops increasing pressure in the cylinders until it has absorbed a large amount of the energy of the moving vessel and the automatic valve opens under a load about equal to the breaking strength of the chain. The chain will be lowered to the bottom of the canal to permit the passage of ships under control. With these safeguards and movable dams to close the canal above and below the lock all contingencies seem to be well provided for.

PROMPT TELEPHONE SERVICE

THOSE of us who have experienced the exasperation of waiting impatiently for an answer to our call may take unction unto our souls from certain statements made by a writer in *Popular Electricity*. In London, observations were made upon 50,000 different calls, and it was found that the time taken for a call, including the time of ringing up and the time of the operator answering the call, was on an average of 5.1 seconds. The time needed for making the whole connection was 28.6 seconds. A similar record, covering over 55,000 calls made in Chicago during 1911, gave the average time taken for the operator to answer a call as 3.1 seconds. The time necessary to make the whole connection which covered the time up to the time the subscriber answered was 25.4 seconds. L. E. M.

HORSE, GASOLENE AND ELECTRIC TRUCKS

INVESTIGATION OF THEIR RELATIVE EFFICIENCY MADE BY THE DEPARTMENT OF ELECTRICAL ENGINEERING OF THE INSTITUTE OF TECHNOLOGY

The Massachusetts Institute of Technology has been giving, the past two years, an example of its methods in the investigation of live business problems, by a determination of the various elements of cost in using motor trucks. It is really a pioneer work, for till now the determinations of the motors' efficiency have come generally from the car manufacturers and hence have been always liable to discussion if not to the suggestion of bias. But with the standards determined by an institution like Technology such an objection is no longer to be urged.

The enormous growth of the motor vehicle industry—a larger number having been sold last year than in all the preceding years—makes certain standards necessary and the business men themselves saw the need and turned to the department of electrical engineering of the Institute for its solution. Funds, including one to care for the main portion of the work from the Edison Electric Illuminating Company, and other contributions like that of $1,000 from Thomas A. Edison, for the discussion of special features of the problems, have been given the department.

The research was entered into in a very broad way. It took up the matter of comparative cost and efficiency of horse-drawn, gasolene and electric trucks; it considered light and heavy loads and it observed the needs of all kinds of teaming from the delivery of department store parcels to the moving of the heaviest freight from terminal to terminal. It has investigated the conditions of freight yards and sought to determine the causes of delay, if any, and one of the future problems to be considered is that of effect of kind of paving on cost of teaming.

What may be the advantages of one kind of truck over another is a matter in which, up to the time of this investigation, there has been very little information. The procedure was first to analyze the services and to determine relations between each kind of truck and the work it is expected to perform. This was done largely by means of the "clocks" of the Boston Delivery Supervision Company, who aided in maintaining the registers and in other details. The clock marks on a tape the performance of the truck to which it is attached, showing how long the wagon is at work, at what speed it travels and how long it rests. The register has been fancifully termed in the West "the machine that counts the driver's drinks." Records from such registers to the number of sixty a day were received at the Institute during last winter, spring, and summer and analyses made of their readings. It may be seen that from such data the cost factors may be determined. It is possible to set apart what the cost is to the teamster of congested streets, inadequate loading or unloading facilities and other matters hitherto only to be roughly estimated.

In the investigation one of the first items to make itself apparent was the limitations of possible work. A horse-drawn truck carrying two tons can be counted on in city streets for a maximum of fifteen miles, while an electric truck in the same work can make thirty-five miles. To do a day's work the horses must keep moving four hours during the time and the motor truck must run five and one-half hours. There is little gain in a nine-hour day in reducing the standing time of the horses to less than 55 per cent. of the whole time, while the motor truck must not stand still more than 45 per cent. of the time.

It is possible, therefore, to name conditions under which the horse-drawn vehicle will be more economical. It is

true that motor trucks have great advantages in rapidity of movement and radius of action over the horse, but at the same time proportions of cost are very important in business. If the cost of hauling merchandise should be very small in proportion to other costs, the matter of a few cents a ton for haulage may really be secondary to such items as reliability and punctuality.

The first important result of the research is here, therefore, that every class of service must be considered by itself, and there can be no general uniform rule. The merchant must base his selection of the kind of vehicle on the requirements of his business.

Some of the preliminary estimates will serve to show the nature of the investigation and its relations to most efficient conduct of this portion of the business. In parcel delivery with a nine-hour day, three trips, four parcels delivered per mile and one minute consumed in each delivery, three-quarters of an hour being allowed for loading and the maximum load being half a ton, the horse-drawn wagon does two thirds as much work a day as either the electric or the gasolene truck and the costs per parcel are 5.4 cents for electric, 5.9 cents for horse and 6.5 cents for gasolene, respectively. The cost per mile for the horse is likewise between the other two costs. In the delivery of coal, which is at the other extreme from parcels, being in large lots and to a single place, with loads of five tons, the horse wagon (three horses, one resting every third day) does about half as much work as either of the motor trucks. The cost of delivery per mile is 47 cents (electric), 55 cents (horse) and 58 cents (gasolene), while the cost per delivery of the whole load is $3.32, $3.91 and $4.07, respectively.

The foregoing estimates are not given as comparisons of the economic fields of electric and gasolene machines, but as the relative performance in services whose hauls are of moderate length.

If, however, it is a requirement in a parcel delivery that two minutes be required by each delivery instead of one there is an increase in the standing time, a reduction in the mileage per day and the cost of delivery is raised to a degree that is surprising. For the horse the increase is 22 per cent.; in the gasolene truck, 30 per cent.; while in the electric vehicle it is 27 per cent. This shows how the introduction of what may seem to be a minor variation may really change considerably the cost relationships.

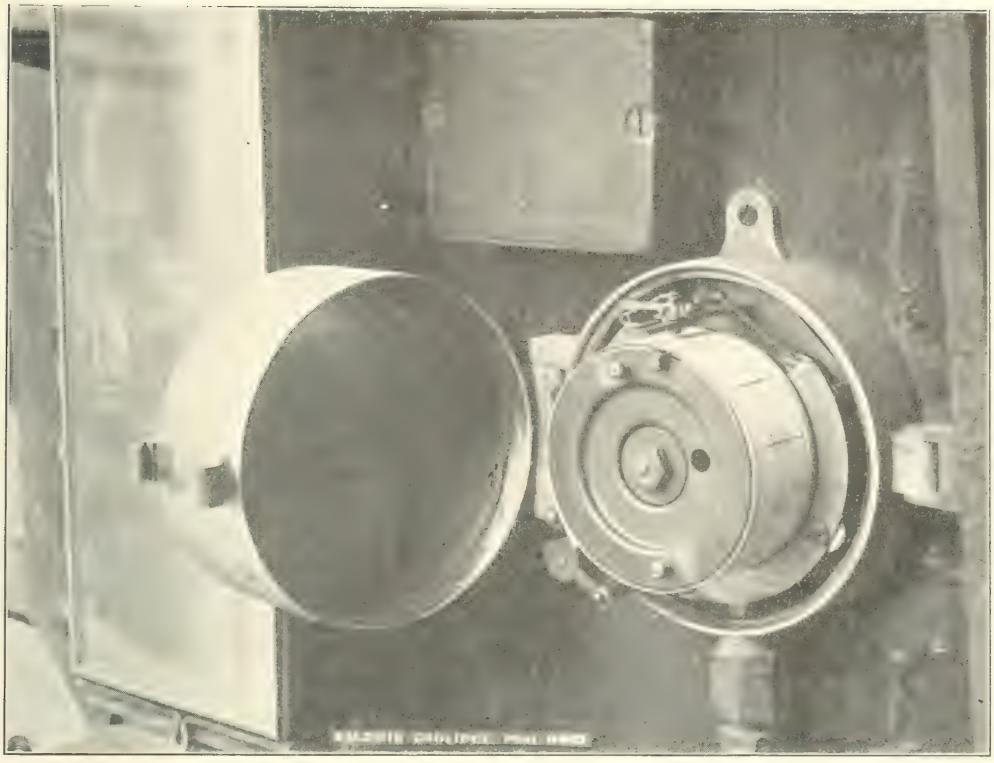
In the matter of total expense the horse cost is again between that of the electric and gasolene trucks.

One of the important matters developed in the research is the lack of uniformity in accounting, which has in the past obscured the real relations between cost and service. It was found that according to the practices of different firms, the drivers' wages were omitted from the operating costs in some cases, and in others rent of garage, while pretty generally items like insurance and taxes were not charged to the trucking and seldom depreciation and the costs of administration.

In connection with the work the investigations were carried on in freight yards and other places said to be congested. In freight receipt and delivery there were considered as separate factors such things as entering, waiting, backing, loading or unloading and going out.

Backing turns out to be a time-consuming operation so far as horses are concerned, for a one-horse wagon requires one and one-half times as long to back to its loading or unloading position as a motor truck; the two-horse wagon twice as long and the four-horse hitch two and one-third times as long. In congested places the motors have another advantage, for the horses occupy valuable space and the motors can work in and out better through moving traffic.

These items are practically the work to March, 1912. Since that date, with renewed support by the Edison company and other contributions the work has been continued by the department of electrical engineering of the Institute as before. The field of observation has been enlarged and other cities have been included in the group from which cost data are received, among them



Register on a large electric truck, taken at 2.30 P.M. Time is shown by the figures; it is a mile from the central line to the edge and the slant lines are the work record. The truck rested from 11.15 till 1.10, made over two miles in one run, rested five minutes and did another two miles, and had been resting half-an-hour when the picture was taken.

New York, Philadelphia, Washington, Chicago, Detroit and Saint Louis together with some of the smaller places. Not only have the automatic registers been used but men have been employed to check the results and there has been a closer personal contact with the superintendents of large garages and the users of individual trucks.

Other difficulties in considering the problems, which have heretofore been done by firms or individuals with a commercial interest in the results, have been very apparent in the last year of the work. There are not as yet any reliable checks or many real standards. The manufacturers usually have a guarantee—a stated mileage for the tires, for example—but abuse by the driver or other items of roads and grades may cause failure to attain the standard. Generally there is a compromise reached that makes the real cost larger than the manufacturers' estimates. The book figures may be misleading. For example if a truck should run 14,000 miles in a year, with tires worn out at the end of 8,000 miles, the books would show only the cost of one set, whereas the second set would be three quarters gone. Of course this would be averaged in a number of years, but would require for it three or four times as long as most firms have as yet owned their trucks. In fact there is here one of the present difficulties, that the automobile truck has not yet been long enough in use for standard figures to be established with reference to its durability. So little is known about this that the figure for depreciation, if any

note is taken in the matter, is as yet a rough estimate.

The estimation of repairs is even more difficult than that of tires, for here the road-surfaces, climate, nature of the care, etc., all enter into the question. When it comes to battery renewals there are other complications and not only is the mileage to be considered, but the number of stops in addition to road conditions and care. Then there is the different cost of electricity in different places and the fact that the price of gasolene varies from that used in the estimates. These suggestions will show how carefully the Institute experts have gone into the matter.

The second of the bulletins on the cost of motor trucking by the department, reporting progress to October, 1912, consists largely of tables and diagrams of cost data which had been collected from operators of cars. In tire renewals for electric trucks the highest cost was found to be in the heavy trucks and here it ran as high as 11 or 12 cents a mile with the minimum of four five-ton trucks at just below 7 cents. The three and one-half ton trucks cost 1.22 to 5.92 cents respectively, the latter approached by the most costly of the two-ton trucks which ran from about 2 cents to 3.31, while the lighter vehicles with two exceptions were rated at 3 cents or less. The tires of the gasolene trucks show a maximum expense in the five-ton vehicles running from 8 cents to about 15; the seven-ton trucks, two of them, show a decidedly lower figure while the lighter vehicles average from 2 to 3 cents a mile.

Repairs on electrical vehicles are practically the same for all weights, the actual renewal figures on half-ton vehicles being in cents per mile, 4.82, 3.46, 2.68 and 3.78, against 3.30, 3.10 and 6.70 cents in five-ton trucks. The gasolene wagons show similar relations of the different classes, with a high spot in the five-ton trucks (15.40 cents) and in general, as might be expected from the multiplicity of parts, stand higher in cost than the electrics, figures of 10 and 11 cents being not unusual. Lubricants, a minor item in these costs, in the electrics mean one-fifth of a cent a mile and in the gasolene cars, nearly nine-tenths. The heavy gasolene trucks all surpass the half cent, half of them going above the cent and one up to 1.86 cents per mile. The last-named figure is the result of a four-year test with a total distance run of 22,300 miles.

The cost of garage has been figured for only sixteen out of a total of ninety-three reports considered and is very variable. For one electric of one ton capacity engaged in wholesale delivery, the figure is as low as $13 per year, while for two others in the same class they are $301 and $307, respectively. The minimum for gasolene was a seven-ton truck at $70 a year, with other figures, $271, $289 and $459.

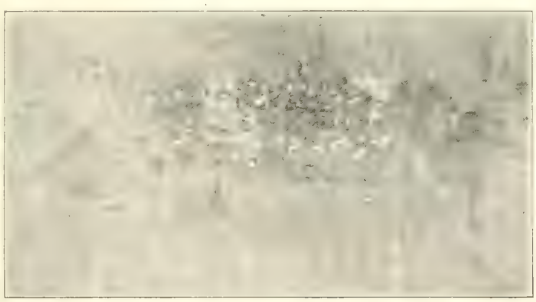
One of the interesting features of the latest report is the comparison of the manufacturers' estimates with the reality as developed for the first time by this investigation. In point of tire cost, sixteen electric trucks give a figure above the manufacturers' and eleven below; while in the gasolene vehicles twenty are above the guarantee and fourteen below. All the five-ton electrics were far above the commercial estimate and three of them more than double, while in the gasolenes of this capacity two were below and seven above with three of them more than double. In gasolene consumption the estimate is a reasonable average, the smallest cars—700 pounds—and the one-ton trucks showing the highest mileage per gallon—ten to twelve miles per gallon in the former and eight to ten in the latter—while the three-ton vehicles went from four to six miles. In the repair costs the electrics showed twenty-five of them above the manufacturers' estimate and six below, while the gasolenes were twenty-three above and nine below. In watt-hour consumption all the electric vehicles but two proved higher than the estimate and many of them twice to three times the estimate while in cost of battery renewals seventeen vehicles were high against nine below the commercial figure. Here the light vehicles depart most from the figure, a large proportion of them being twice the estimated cost, while the heavy trucks were pretty close to the manufacturers' estimates.

KITCHEN-MIDDENS AS ETHNOLOGICAL RECORDS

WHAT THE WASTE HEAPS OF EARLY MAN TELL US ABOUT HIS CUSTOMS AND HABITS AND HIS GRADUAL PROGRESS TOWARD CIVILIZATION

BY HERVEY W. SHIMER

As our present city waste dumps will give to the future paleontologist a pretty good conception of some phases of our material civilization, so the waste allowed to accumulate around the dwellings of early man give us a rude conception, at least, of his stage of development. Very early man, by a trait which inheritance has made comprehensible to us, threw the waste of food and clothing immediately outside his dwelling, there to accumulate. To such masses of débris the name kitchen-midden, literally kitchen refuse heap, has been applied. Since in many regions the food of early man was largely shell-fish, and these heaps of refuse would consist largely of shells, the name shell-mounds is also applied to them.



A small kitchen-midden: Gardiner's Island, New York. The numerous white shells outline the depression.. Upon the shells rests the horizontally and evenly bedded alluvium. The upper margin of the photograph is the top of the cliff.

Kitchen-middens vary much in size, from a length of a foot to that of a mile or more and from a thickness of a fraction of an inch to that of 100 feet; from the few shells, bones, and charcoal,—the refuse of a solitary hunter about his temporary camp, to the accumulations of a large village inhabiting the same locality through many centuries. Usually they have a diameter of 50–100 feet and a maximum thickness of two to five feet. In the permanent villages the dwelling came in time to occupy a depression in the accumulated mass. Besides being a repository for the waste of food, clothing and implements of war and hunting, they likewise were in many parts of the world used as burial places; just as many lowly tribes today bury their dead beneath their dwellings to keep them from disturbance and to have the protection of their spirits against enemies.

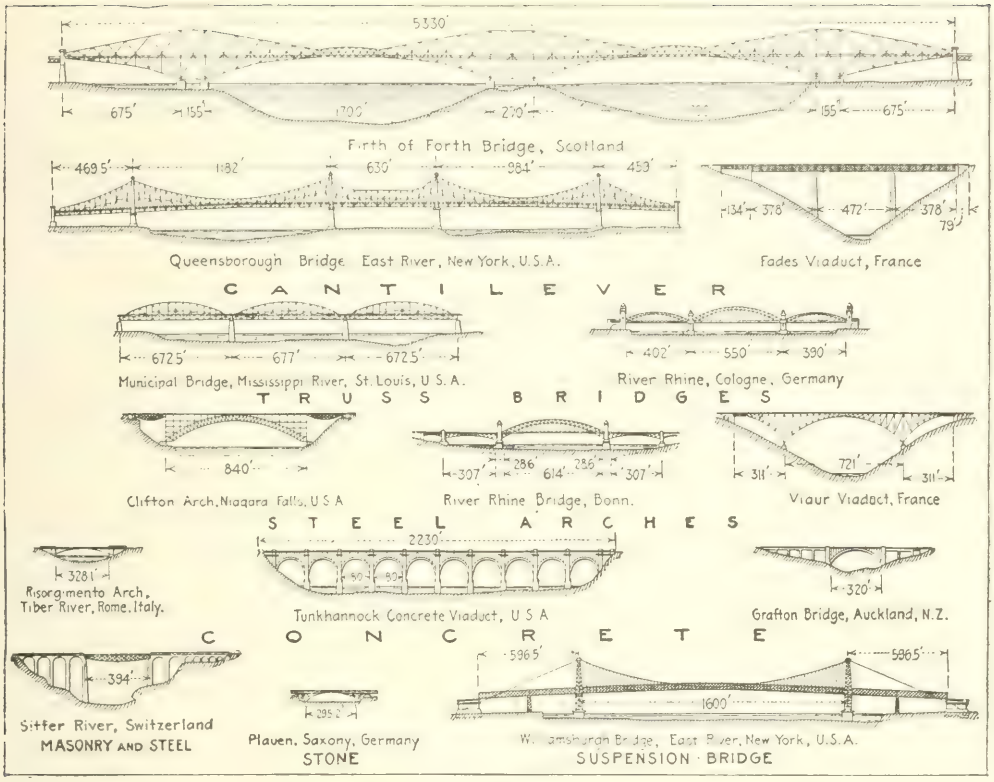
The distribution of kitchen-middens is world wide, they are found on all continents,—North and South America, Europe, Asia, Africa and Australia. They usually occur on the margins of bays or inland along streams and lakes. They frequently, in this country, occupy the same sites as the later white settlements and for the same reason,—accessibility to water, food, and wood. The character of the middens naturally varies with the character of the food. Along the ocean margins the waste was marine shells and the bones of fish and mammals; inland it was fresh water shells and the remains of land animals, though the presence here of some marine forms indicates a system of traffic such as was practised by the Indians upon the arrival of the whites.

The shell-mounds of the coasts of Maine and northeastern Massachusetts contain principally the remains of the clam, oyster, quahog, hen clam, scallop, deer, beaver, wild turkey, great auk, and many kinds of fish; with these occur fireplaces, charcoal, flint implements, and a little pottery. Many are the remains of animals now absent or very rare in these regions; among these are the oyster, quahog, wild turkey, and great auk. The presence in a midden at Ipswich Mass., of human bones broken into short pieces as for the cooking pot gives indication of cannibalism. This practice has been shown to have occurred at other places, as Florida, along the Atlantic Coast.

Kitchen-middens vary in abundance with the suitability of a region for habitation. In the San Francisco Bay region 425 good sized mounds have been counted. They are also very numerous along the Atlantic Coast from Newfoundland to the West Indies and around the Gulf. This abundance was called to the writer's mind when making some geological observations on Gardiner's Island with Prof. W. O. Crosby. This small island lies south of Connecticut, at the east end of Long Island. On the east side, within a length of 100 feet of sea cliffs, the ocean waves had sectioned three small middens. The photograph shows one where the fire had been built in a depression in the brown loam; the fire has turned to a red color the four to six inches of soil bordering the pit. At the place of sectioning the depression is two feet wide by a foot deep and covered with almost a foot of alluvium washed from the slightly higher slopes to the north; within it were collected charcoal, burned pebbles, the very abundant scallop (Pecten irradians), quahog (Venus mercenaria) clam (Mya arenaria), oyster (Ostrea virginiana), also a few specimens of the decker (Crepidula fornicata), jingle shell (Anomia), blood clam (Scapharca pexata) and a fulgur, besides the bones of some fish and birds and broken pottery. Other middens thus sectioned were noted along this coast. For the retreating sea cliffs to expose so many at any one time the total number on the island must be very large.

Kitchen-middens are also very abundant in France, Denmark, Scotland, Italy, and Japan. In northern Italy they have received the name of terramara (bitter earth). They contain few or no shells but are phosphate deposits. These represent the accumulations beneath dwellings built on piles; and their slow accretion took place during the time when this region, especially that lying between the River Po and the Apennines, was gradually changing from a condition of shallow lakes, or marshes with frequent inundations, to that of dry ground. These dwellings began apparently at the end of the Stone Age there and reached their greatest development about the fifteenth century B. C. The terramara deposits are apparently intermediate between the kitchen-middens proper (shell-mounds) of northern Europe and elsewhere and the lake dwellings of Switzerland; the different kind of accumulated waste indicating both the kind of dwelling used and food eaten.

The remains of shell-mounds (kitchen-middens proper) indicate that they were accumulated by peoples but slightly if at all acquainted with agriculture, whose subsistence depended mostly upon fishing and hunting, and who were largely in the Neolithic period of culture. Some mounds in the San Francisco Bay region must have been occupied for four or five thousand years at the least. This estimate is based largely upon the probable number of shell-fish, birds and mammals eaten by one individual and the approximate number of individuals in the village, reckoning each depressed area as the dwelling place of one family. Some of the mounds were occupied after the advent of the whites. The same is true on the Atlantic Coast. In the Ipswich mound referred to above, it was only near the top of the mound that any objects of European make were found. Similarly on this coast the presence of rare or extinct species gives evidence of the lapse of many centuries since early man began here his primitive housekeeping. In the Americas the Indian is, at least in many cases, known to be the direct descendant of the kitchen-midden inhabitants.



Through the courtesy of the *Engineering News* we are able to present to our readers a diagram of some of the world's largest bridges. These are all drawn to the same scale and show the principal examples of the cantilever type, of truss, steel arch, concrete, masonry, and suspension bridges. The largest of these types is shown in each case. The Firth of Forth Bridge has the largest cantilever; the Municipal Bridge, the largest single plain truss; the Clifton Bridge, the largest steel arch; the Risorgimento Arch, the longest concrete arch; the Plauen Bridge, the longest stone masonry arch; and the Williamsburgh Bridge, the largest suspension bridge.—L. E. M.

TRANSPARENCE OF METALS

It has been known for come time that certain metals when heated become more or less transparent. It has now been shown that a sheet of glass covered with an extremely thin layer of silver also becomes completely transparent when heated in the presence of oxygen. Its transparency becomes visible at 240 degrees and becomes perfect at 390 degrees. It is supposed that there is a temporary combination of oxygen and silver which is afterwards broken up as there is no change in weight before and after the experiment. Thin leaves of copper heated under the same circumstances become transparent and emit an emerald green light. L. E. M.

A SEVERE TEST

On June 20 last, at Coatesville, Pa., two steam boilers of different types, one called the sectional and the other the radial stay, were filled with water which was then converted into steam by oil fires. The water was entirely boiled away in the sectional boiler which stood the test until the end, but the radial stay boiler exploded before the water was entirely boiled away.

L. E. M.

THE SOCIETY OF ARTS OF THE MASSACHUSETTS INSTITUTE OF TECHNOLOGY

The Society of Arts was established as a department of the Institute by President Rogers in 1861. It is especially devoted to the general dissemination of scientific knowledge, and it aims to awaken and maintain an interest in the recent advances and practical application of the sciences.

Any person interested in the aims of the Society is eligible to membership.

The annual dues are $3.

RICHARD C. MACLAURIN, President of the Institute.
ISAAC W. LITCHFIELD, Secretary of the Society of Arts.

EXECUTIVE COMMITTEE

THE PRESIDENT
ELIHU THOMSON
JAMES P. MUNROE
THEODORE N. VAIL
ARTHUR D. LITTLE
FREDERIC H. FAY

THE SECRETARY

BOARD OF PUBLICATION

D. F. COMSTOCK
SELSKAR M. GUNN
ELLWOOD B. SPEAR
LEWIS E. MOORE

I. W. LITCHFIELD, Editor

SCIENCE CONSPECTUS is published December, January, February, March and April.

WASHING MONEY

THE United States Government has recently begun to wash and iron its soiled paper money by machinery. It is expected that this machine will save the government a large amount of money and also prove an economy to bankers in all parts of the country. The money passes through the machine between two duck belts which run over copper rollers. These rollers are so shaped as to impart a scrubbing motion to the soiled currency. The whole washing operation is carried out in a 100-gallon tank filled with a solution in which a special soap is dissolved. When the washing is completed, the bill is run through a tank of clear cold water and then a jet of air whisks it to another duck belt which carries it over gas-heated drums which dry the paper. It takes less than two and a half minutes for the bank note to pass through the machine. A supplementary machine irons the bills by passing them over heated drums and subjecting each one to pressure of compressed paper rolls. L. E. M.

AN AUTOMATIC WAITER

ONE of the principal items of cost in running a restaurant is that of waiter service. It is reported that an Australian has started the thin point of the wedge into the cost of living in inventing an electric waiter which is operated by the customer seated at his table.

A wooden frame holding the menu card is fitted with push buttons opposite each item, and "pressing the button" rings a bell in the kitchen and displays the order and the table number. The kitchen apparatus also prints a check the original of which comes to the customer, with a duplicate on an endless tape. This device has been in successful use in New Zealand.

IS THE ATLANTIC COAST SINKING

FROM time to time the assertion is made that there is a general movement of the earth's crust along the edge of the ocean. The Atlantic Coast of the United States has recently been studied by Johason, a French geographer, who has drawn the conclusion from his studies that the disturbances reported have been purely local and that there is not a general coastal settlement.

Of course the studies of any one man are extended over a comparatively short period of time and do not serve to tell us whether or not the great coastal movements, which we know have taken place in geologic times, are at present occurring. L. E. M.

VENTILATION FROM A NEW STANDPOINT

British physiologists have devoted a large share of their energy in recent years to the problems connected with respiration. Leonard Hill is perhaps the most prominent of a group whose names are associated with fruitful studies in this field. It is, therefore, interesting to consider a summary of his views concerning ventilation. Such a statement in a condensed and popular form he has embodied in a presidential address before an English association and it has been reprinted by *The Popular Science Monthly.*

The article reads like a stenographer's report and various slips of the tongue—or instances of careless proofreading—appear in it. These can be overlooked; though a New Englander resents the obvious confusing of the intellectual Laura Bridgman with the hapless defective known in physiological literature as "Strümpell's patient." The really important matter of the address can be divided into two parts—first, a review of the doctrines previously held and of the transition to current beliefs and, second, the considerations which are more distinctly the speaker's own.

The readers of this magazine are so familiar with prevailing views that only the briefest statement need be made. It has been established that lack of oxygen is practically unknown under the worst conditions of crowding, and restricted air-supply, so long as we are observing subjects at the sea-level or at ordinary altitudes above it. Hill points out effectively that in the most intolerable situations in shops, mines, or tenements the oxygen supply is more liberal than in the celebrated health resorts of the Alps. Increase of carbon dioxide to the percentage which clearly disturbs the human system is only the remotest possibility. In the light of these facts men of science turned for a time to the hypothesis of "crowd-poison" to account for the untoward effects of deficient ventilation. It was maintained that organic exhalations from the respiratory tract, the mouth, the skin, and the clothing must accumulate in the stagnant air.

Crowd-poison still has its protagonists but can be said, on the whole, to be in disrepute. Hill makes light of it. He recognizes, of course, that an odor in a stuffy room must have a chemical basis but he points out that such odors cease to be apparent to persons who continue to breathe the vitiated atmosphere. The assumption is made that the sensation completely measures the influence of the odorous material on the organism. This appears to the reviewer to be utterly unsafe. Crile has abundantly proved that central anæsthesia does not insure the neutralization of the effects of stimulation through afferent paths.

Hill fully endorses the teaching to which we have become accustomed that there are but two qualities in the air of ill ventilated places that are at all likely to make themselves felt, high temperature and high humidity. In fact, it might be claimed that only one of these, high temperature, need be considered. For high humidity is not significant in connection with moderate temperatures. Lack of movement in the air might be mentioned as another detrimental condition but this is really tributary to the two just mentioned. If there are no currents, the air next the skin of the face and hands is not briskly exchanged for fresh portions and it becomes warm and moist. Hence the surface of the skin would be as warm in a room filled with still air of a certain temperature as it would in another room where the mercury was standing several degrees higher but with the air in circulation. Hill is an advocate of the electric fan.

But we must pass to the more novel parts of the address. The speaker tells us that when the ideal of the architect and the engineer is attained—the older standards being sought—the result is far from satisfactory. The air of the work-room or the school is chemically correct, its temperature is 68° F., there are no draughts,—but the occupants are

sluggish and depressed. Very likely they complain of the ventilating system. The cause of their dissatisfaction *is*, in a word, that the environment is *unstimulating*. We have been so anxious to eliminate disturbing factors that we have produced an unwholesome calm. The human body is not accustomed, to the suspension of external stimulation; it has been developed under such spurring and tends to lose tone and efficiency when shielded from it.

If we analyze the effect of the absence of stimulation we shall probably be safe in concluding that one result is a vascular relaxation, presumably with some decline of the arterial pressure. Another is a softening of the musculature. Both these changes are such as favor mental passivity and scattering. They are characteristic of the approach to sleep. When we go to bed we aim more or less successfully to exclude stimuli of all sorts and we welcome the ensuing lapse through reverie to unconsciousness. But when it is our purpose to concentrate the attention we avoid absolute comfort. We do not resort to a hammock or a morris-chair. Hill affirms that when we have neutralized draughts and secured a mild, uniform temperature we have shut out possible promoters of nervous activity. He would therefore prefer that ventilating and heating systems should not work too well. A touch of chilliness and a perceptible air current he would regard as desirable. Certainly it is worth while to consider that the most comfortable climates do not produce the dominant races and we have perhaps pampered ourselves unwisely by approximating such climates in our homes.

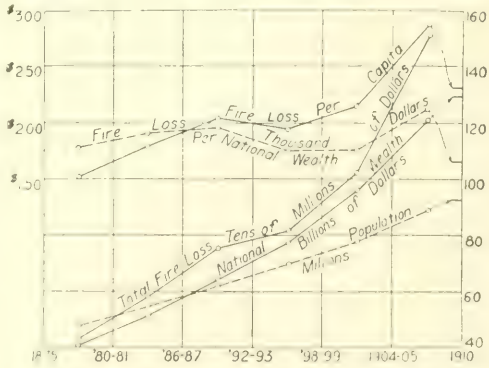
There is a corollary to Hill's contention which might not be foreseen. It is that low diet makes people seek the lifeless air of ill-ventilated houses. They cannot meet the demands of more bracing conditions because they have no fuel to spare. The case of the Newfoundland fishermen is cited: they are so underfed that they huddle in warm cabins and the hardening effect of their laborious occupation is more than counteracted by the relaxation under shelter. They are dying at an appalling rate from tuberculosis. Here, then, we have a fresh protest against the doctrines of Chittenden. Hill maintains that colder rooms with air in motion will make us more hardy and alert, but that liberal feeding must be maintained to meet the tax upon the heat-producing tissues.

PERCY G. STILES.

FIRE LOSSES IN AMERICA

THE historical progress of fire losses in the United States for the last thirty-six years is shown by the accompanying diagram, produced from the *The Engineering Record*.

In order to smooth over inequalities due to extreme losses one year and considerably lower ones the next, the chart has been figured out on the basis of averages for six years, and is so plotted. There are five curves presented, of which the one depicting the total fire loss, in tens of millions of dollars, shows the greatest rate of increase at practically every point across the chart. It is growing faster than the national wealth, and very much faster than the population.



During the 36 years covered by the chart the fire loss in the United States has amounted to the stupendous figure of $5,120,622,540. This is more than 7 per cent on the average value of national wealth over this period of time. As a matter of fact, the present annual gain in wealth, which is about $4,600,000,000, represents only the capital at 5 per cent, of our annual fire loss which amounts to $230,000,000 per year.

SCIENCE CONSPECTUS

VOL. III JANUARY, 1913 NO. 2

AN HONEST LABEL

SOME OF THE METHODS EMPLOYED TO "COMPLY" WITH THE LABELLING PROVISIONS OF THE PURE FOOD LAW AND AT THE SAME TIME MISLEAD THE PUBLIC

BY A. G. WOODMAN

THERE is a clause in the Federal Pure Food Law under which an article shall be deemed to be *misbranded* "if the package containing it or its label shall bear any statement, design, or device regarding the ingredients or the substances contained therein, which statement, design, or device shall be false or misleading in any particular."

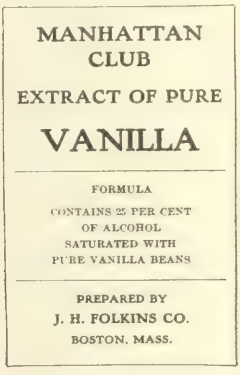


Figure 1. A Weak Extract Although "Saturated"

Not all of the work of the chemists engaged in the control of food adulteration, fortunately, is concerned with the detection of actually poisonous or even deleterious substances. As a matter of fact, the greater share of their energy is directed to learning whether or not the label on a food package correctly represents the character of its contents. Much of the present propaganda in the interest of pure food, especially from the standpoint of the consumer, can be summed up in the three words that are at the head of this page —"An Honest Label." In many cases accurate and true statements of the contents of the can or package constitute the only protection needed by the purchaser, and are fully as efficient and much cheaper than prosecutions or restrictive measures. The reasons for using antiseptics and artificial colors, and otherwise adulterating foods, may be questioned, but no one will deny the right of the consumer to know it whenever adulteration has been practised.

Plain labelling constantly involves the meaning of words. The courts have universally held in construing all law that words shall be given their ordinary meaning in matters of interest to the public, and the meaning of words used in their ordinary sense is a question for the courts. In practice, however, it seems to be the idea of certain manufacturers of foods that a label is placed on a package for the purpose of conveying *mis*information as to its contents.

Even common household terms, formerly employed to convey the meaning of superior quality, are used as a mantle to conceal false pretense. "Absolutely Pure," "Warranted a Superior Article," are only trade names which to the initi-

ated have no more significance than the term "Strictly Fresh" as applied to eggs. The term "Home Made" covers some of the most highly developed products of synthetic organic chemistry. "Mrs.

Figure 2. "Dutch" Products from Michigan

Williams' Home-Made Ketchup" more likely than not consists of grated turnip, filled with starch, colored with eosin, preserved with benzoate of soda and flavored with methyl valerianate and other products of the chemists' art.

Elements of a Label

The ideal label should tell *where a product was made, by whom it was made, and its true nature and substance.* All of this, and any additional information which the law requires in order to make known any adulteration by addition or deficiency should be in such *position, type,* and *terms* as will at once be *seen, read* and *understood* by *the average purchaser or consumer.*

Plain labeling of this kind, fair in theory, is difficult to put into practice. Investments are so enmeshed in the web of fancy which advertising agents and label designers, without regard to the facts and wishing only to emphasize every food term indicative of purity and quality, have woven throughout the food industry, that the changing and adjustment of labels means financial loss and widespread disturbance. The manufacturers object especially to any statement regarding the age of the product or the location of the factory and they have in general not been obliged to furnish this information on the package. It cannot be gainsaid, however, that these statements may be to the consumer indices of superior or inferior quality and the omission of them in the labeling is a special privilege to the food industry and a prejudice to the consumers' rights.

One thing, nevertheless, is to be insisted upon and that is that the label *shall tell the truth.* This has been the requirement for years in trade-mark law and the same principle holds true as regards labels that are to be respected by the food laws. Trade-mark protection has been denied by the courts, for instance, to a product labelled "Balsam of Wild Cherry," when the balsam was not made from wild cherry; to the "Balsam of a Thousand Flowers," when the compound was not derived from flowers;

Figure 3. Cotton-seed Oil Masquerading as Olive

to "Laird's Bloom of Youth," labelled to be "free from all mineral or poisonous substances," when the so-called article

contained carbonate of lead and other noxious ingredients. In this spirit was framed the clause in the Pure Food Law quoted in the opening paragraph, and it will be of interest to consider some specific examples which show the need for such enactment in the case of food labels, that they may fulfill their purpose of *keeping the consumer fully informed.*

Misleading Labels

Labels may convey information which is perfectly true *per se*, or which is a matter of honest opinion, but which is

Figure 4. Italian Macaroni made in America

so arranged or stated as to convey a wrong impression. A label reading

SUPERIOR
IN
QUALITY, PURITY AND FLAVOR
TO ANY
OLIVE OIL
ON THE MARKET

especially when the lower part of the label bears a representation of a dove carrying an olive branch, could hardly help giving to the mind of a purchaser who sees it upon the grocer's shelf the impression that it is olive oil. Yet it will be observed that the label does not actually state that the bottle contains olive oil, and as a matter of fact the sample was a mixture of cotton-seed and corn oils. Whether or not this mixture is superior to olive oil is a question open to argument.

In the same way, when one reads upon a bottle of spring water the statement "This Spring Water was placed FIRST in the Report of the State Board of Health,"

OLEO-MARGARINE.

BUTTERINE.

Figure 5. Compare this with Fig. 7 for "Plain Legible Type"

it is surely pardonable for him to assume that the spring water occupies this high eminence by virtue of its quality and exceptional purity. Yet the only reason for placing this water first is that the list of spring waters examined by the board is arranged alphabetically and the name of this particular one begins with the letter "A"!

Still another instance will illustrate the ingenuity displayed in imitating labels on packages of established reputation in order to convey a similar impression in behalf of an article of questionable value. Manufacturers of cream of tartar baking powders often put on the label a statement authorizing grocers to guarantee that the powder is free from alum or other adulterants. The can of the "Boston" baking powder used to bear a label reading after this manner: "All grocers are authorized to guarantee bread, cake, pastry and all products in

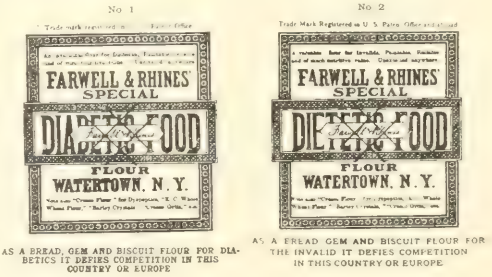

No. 1
FARWELL & RHINES
SPECIAL
FLOUR
WATERTOWN, N. Y.
AS A BREAD, GEM AND BISCUIT FLOUR FOR DIABETICS IT DEFIES COMPETITION IN THIS COUNTRY OR EUROPE
No. 2
FARWELL & RHINES
SPECIAL
FLOUR
WATERTOWN, N. Y.
AS A BREAD, GEM AND BISCUIT FLOUR FOR THE INVALID IT DEFIES COMPETITION IN THIS COUNTRY OR EUROPE

Figure 6. An "Improved" Label

which our powder is used free from alum, lime, ammonia, terra alba, Rochelle salts or anything injurious as a result of

its use." At first sight this guarantee would appear to be of the kind used on genuine cream of tartar powders and

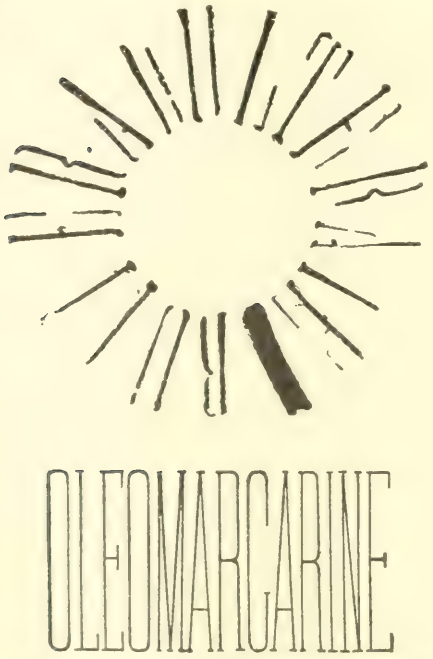


Figure 7. The Manufacturer's Idea of "Plain Legible Type"

even stronger in its protestation. The little "joker" lies in the fact, however, that they do not guarantee that the *powder* is free from these harmful things but that the *bread*, *cake*, etc., is free. As a matter of fact the powder contained alum, terra alba, and ammonia, but since these are partially changed during the baking they are not present in the same form in the final product. Hence the statement is theoretically true although ingeniously deceptive.

In the Manhattan Club Extract of Vanilla (fig. 1), the same policy of deception is carried out by the use of the word "Saturated," conveying the meaning of great strength. In reality the extract is a very weak one since 25 per cent. alcohol will dissolve but little from the vanilla bean. Makers of high-grade extracts use much stronger alcohol, even of 60 per cent. strength, in making vanilla extract. Plain water might have been used in making the extract just about as well. To be sure, it would take practically nothing out of the vanilla bean, but then it would be "saturated" (for water).

The misbranding clause of the law takes a step further, and a very natural one, too, when it recognizes the fact that a label may be misleading pictorially or from its design, without the use of words at all. The picture of an Arab on horseback and of a lady in the costume of the island of Java on a can of coffee conveys the idea as to its origin just as plainly as if the words "Mocha and Java" were there.

The picture of a Dutch windmill on the package of Holland Rusk (fig. 2) would probably be sufficient, taken in connection with the name itself, to impress the purchaser with its foreign origin even if he were not told definitely in large letters that the product is "Made in Holland." Since the passage of the Pure Food Act, however, he is vouchsafed the interesting information that it is Holland, *Michigan*, where these Dutch windmills dot the landscape.

Figure 3 is from a can of "Extra Fine Olive Oil" and, while not an especially good example of the photographic art, shows an Italian girl picking olives from the tree and in the upper corner a portrait of the King of Italy. From the standpoint of plain truth this label would be

Figure 8. "Compound" Packages evasively marked

greatly improved if it showed negroes picking cotton in a southern cotton-field, and a representation of the President of the United States, for the contents

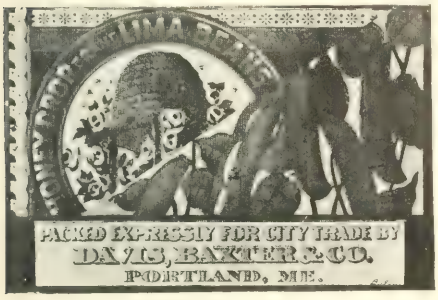


Figure 9. Note the word "Soaked" just under the Beehive

of the can consisted almost entirely of American cotton-seed oil.

Another form of this pictorial misrepresentation is seen in figure 4. It is a common occurrence to find articles of domestic manufacture labeled in imitation of foreign products. Especially is this so when the imported goods, by reason of inherent quality or popular demand, have achieved a considerable reputation. In the macaroni label the view of the Bay of Naples, with the volcano in the background, the people in Italian peasant costume eating macaroni in Neapolitan style, even the characteristic sailing craft and the insignia of the Italian merchant marine in the upper corner conspire to confirm the belief of the unwary purchaser that this is truly an imported brand of macaroni. The only discordant note in the label is the line "Manufactured in New York State" which was printed on the label at the earnest request of the government food officials. Although out of harmony with the rest of the picture, it imparts valuable information to the consumer.

It is not always possible to convey this warning information to the consumer in so direct and positive a manner as in the case just mentioned. It sometimes happens that the deceptive part of the label consists in a word or phrase which legally is all that must be changed. This change can be made by the producer in a liberal spirit or it can be made so as to just comply with the law. There are producers and producers, and while some meet the officials more than half way, others will not step more than an inch over the line. Figure 5 shows a diabetic flour, the sale of which was highly objectionable in that it contained a very large proportion of starch. The illustration on the left is the original label and the one on the right shows the manufacturer's method of compliance with the law. By eliminating all reference to its diabetic use, the product is no longer illegal, but the change from the word "Diabetic" to "Dietetic," as shown in the figure, is not very strong evidence that the manufacturer of this product has the welfare of the consumer much at heart.

Even the very words or marks that the Government requires to be placed on

Figure 10. Proper Use of Word "Style"

certain foods to notify the purchaser of their inferior quality may be so construed or distorted as to appear to have a distinctly different meaning. For example, it is

required that renovated butter shall be marked on every print or package with the words "PROCESS BUTTER" or "RENOVATED" in order that it shall not be sold as genuine butter, it being as a matter of fact a product which has been worked over and purified; in other words it must be marked with a qualifying term or word so that it may be known to the purchaser that it has gone through this treatment. Does this requirement phase the producer? Not a bit, as witness the following advertisement clipped from the daily paper: "The U. S. Government says that every tub of *B. & M.* brand of renovated butter is PURE, and that

Figure 12. Evasive Use of Word "Style"

Uncle Sam guarantees it so, and that every package shall be branded 'RENOVATED' to show its quality."

Illegible Type

Another large class of labels which do not measure up to the standard set in our discussion of an ideal label comprises those in which the information required by the regulations is put on to be sure, but in such small type or so obscurely as to defeat the purpose of the requirement. The ideas of the manufacturer as to what constitutes "plain, legible

Figure 11. Compare Prominence of "English" and "Style"

type" are often at variance with those of food officials.

In the original requirement regarding the labeling of oleomargarine to distinguish it from butter, the only specification was that the word "oleomargarine" or "butterine" should be printed on the package in "plain Roman type" of a certain definite height. The style of type that was in the minds of the State Board of Health is shown in figure 6, the manufacturer's conception in figure 7, which shows facsimiles of stamps in actual use. The word oleomargarine is printed in skeleton letters, although of the required height. The hieroglyphic at the top is the phrase "Adulterated Butter."

Figure 13. A "Compound" Package Not Plainly Marked

Especially good illustrations of this class of labels are to be found among the so-called "Compound" goods. It has been in the past, and still is in certain places, permissible to sell articles containing cheaper substitutes provided they were not injurious to health and if they were plainly marked with the word "MIXTURE" or "COMPOUND." Some of the most interesting cases of dishonest and evasive labels have been perpetrated under cover of this provision of the law. The word "Mixture" is not so common, it apparently not lending itself so readily to purposes of deception, but the word "Compound" can be so used as to represent to the purchaser the idea of an improved process of which he is getting the benefit. This is especially true when the word is used in a sentence or phrase, as "Warranted the Best Compound," or "Specially Compounded for Family Use." The word has been often woven into the design of the label or tucked away in some obscure corner so as to escape detection. The spice packages shown in figure 8 all bear the word

Figure 15. Plain Labelling

"Compound" in "plain, legible type," although much less diligent search

Figure 14. An Honest Label

will be needed to show the words "Pure," "Fine" or "First Quality" on some of the same packages. On one of these packages the word is apparently missing, but if the cut were large enough it would be found that on the side of the can is printed a pleasant tale relating how of all the mustards examined at the World's Fair the award was made to this one as "the finest mustard compound."

A parallel case is that of the requirement that old and mature vegetables which have been soaked in water and then canned shall be marked with the word "SOAKED" printed conspicuously on the labels. It is sometimes put on in some such way as the following, copied from a can of soaked peas: "These goods are prepared from selected stock and soaked in the purest artesian well water," thus giving the impression that the soaking is an essential part of some superior method of preparation. Figure 9 shows an instance where the word "SOAKED" is not given striking prominence. Possibly the statement on the label "Packed expressly for city trade" conveys a gentle thrust at the degree of familiarity of urban residents with the genuine products of the farm.

Under the regulations for the enforcement of the Federal Food and Drugs Act it is forbidden to use a geographical name in connection with a food product not manufactured in that particular place,

Figure 16. Example of "False Statements"

or to use a distinctive foreign name upon an article of domestic origin except as an indication of the type or style. That is, the characteristic foreign name must be modified by the word "type" or "style" if the food is not from the exact geographical locality implied. Figure 10 shows such a case in which the word "Style" is exhibited in large type and as prominently as the principal word on the label. This is not true to the same extent, however, in the label shown in figure 11, and this decreasing scale of prominence reaches perhaps its low-water mark in figure 12, where by close scrutiny the word "Style" can be found coyly hiding between "Japan" and "Rice."

In the package of self-raising buckwheat flour shown in figure 13, it is interesting to note the prominence given to the word "Buckwheat," it appearing in large letters in various places on the label as well as in several of the medallions. This preparation contains in addition to the buckwheat a considerable proportion of the cheaper wheat and corn flours, such a mixture being in fact preferred by many to the straight buckwheat. Such being the case, there would seem to be no valid reason for not stating the fact that it consists of such a mixture openly, and giving it as much prominence as is given to the word "Buckwheat", instead of assigning it the obscure position that it occupies at the lower right hand corner of the label.

After these instances of labels obscurely marked by manufacturers who evidently do not desire that the purchaser shall know the exact character of the product, it is rather refreshing to see the two examples shown in figures 14 and 15, where the producer obviously does not fear to call a spade a spade, and very likely does not find his sale of these articles diminished by reason of his frankness. A label of this kind, it must be confessed, is, however, somewhat of a rare bird.

False Statements

The third and last form of dishonest label that it is necessary to take up is

Figure 17. Label Entirely Incorrect

that in which incorrect or false statements are included. These may depart very widely from the ideal label or from the ordinary ideals of common honesty, and

in many cases would pass unchallenged were it not for the watchfulness of the food officials. The most positive and direct statements on the label may be absolutely controverted by the analysis of the product. Hundreds of instances might be drawn from the packages of patent medicines to illustrate the point, but one will suffice, chosen because the analysis is one of many made in the Institute laboratories. The label on a package of Dr. Fahrney's Teething Syrup contained the following statements among others: "A sure remedy for all ailments incident to babes from one day old to two or three years. . . . Contains nothing injurious to the youngest babe

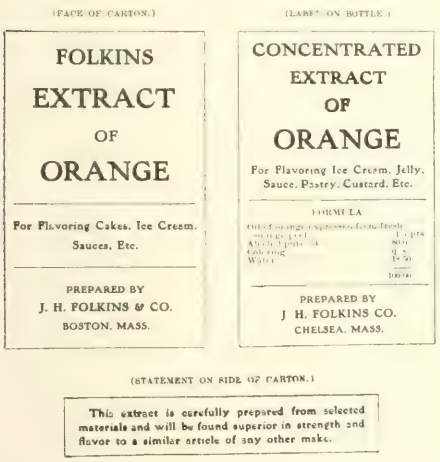


Figure 18. A Contradictory Label

. . . Mothers need not fear giving this medicine to the youngest babe, as no bad results come from the continued use of it." Yet this preparation was found upon analysis to contain alcohol, chloroform and morphine!

But it is not necessary to go to the patent medicines to get examples. Similar instances can be found in food products, although as a rule they are not so flagrant. The can of "Digesto" coffee shown at the left in figure 16 bears the statement that it "Contains no caffein or tannin," and yet a chemical analysis of the product showed that it contained about 12.50 per cent. of caffetannic acid, which is the tannin of coffee, and 1.05 per cent. of caffein; that is, of both of these it contained practically the same amount that is present in ordinary coffee. A large shipment of this coffee was seized by the government authorities en route to Boston from New York and was released by the courts only upon the filing of a bond that the objectionable portion of the label would be eliminated. Hence the revised label shown upon the right in the figure.

Some years ago, before the food officials were so fussy, a well-advertised breakfast food bore a statement on the package that was decidedly reprehensible, in that in addition to being untrue it was liable to prove a distinct injury to a class of invalids who might be misled by it. In the reading matter on the side of the carton was the statement: "This food, being almost entirely of pure gluten, is highly recommended for diabetics or those of weak digestion." The product contained not over 14 per cent. of gluten but did contain approximately 75 per cent. of starch, the very thing that diabetics are trying to avoid. A diabetic patient who used this product, relying upon statements like the above, would in reality be choosing a quick method of committing suicide.

The sample shown in figure 17 is of interest because so many misstatements are condensed into one label. In the first place, the name of the firm is a fictitious one, the product being as a matter of fact made and marketed by an entirely different company. Further, the material, although labeled to imply that it is of French origin, is entirely a domestic product. Finally, the substance is not coffee at all but a mixture of chicory and roasted cereals!

It is not unusual to see on a label itself a flat contradiction, as witness the orange extract shown in figure 18, which furnishes to the thoughtful purchaser a bewildering variety of information. The label on the carton, which is the only part of the package that the customer sees until he has purchased it, not only affords no intimation that the article

is not a standard extract but actually asserts it to be "superior in strength and flavor." The label attached to the bottle represents it as a "Concentrated" extract, and the formula, which is the truthful part of the label, shows it to be only one third of standard strength.

One more illustration of this class of labels must suffice. Figure 19 shows in the upper portion a photograph of a label in use prior to the passage of the Pure Food Law, and below, the same label as it appeared afterward. The change is evident and the natural inference that would be drawn as to the amount of

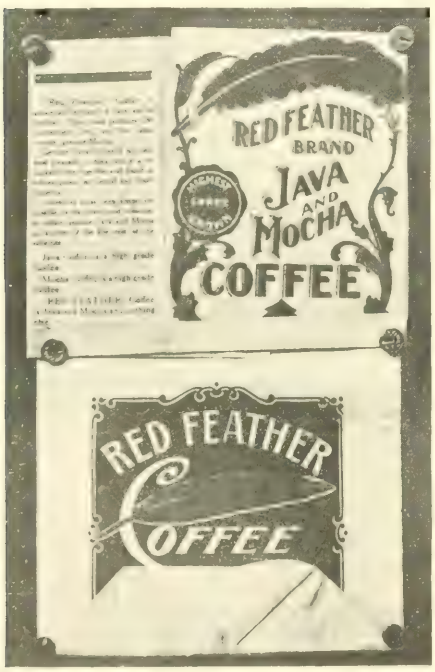


Figure 19. One Effect of the "Pure Food Law"

Java and Mocha coffee that was present at any time is the correct one.

These illustrations might be greatly multiplied but enough have been given to show that there is work to be done by some one if food labels are to tell the truth, the whole truth and nothing but the truth. The question is not one of actual danger to the public, of possible injury to the consumer, but it is perhaps of only a degree less importance that the purchaser should be protected in his inherent right to know what he is buying and paying for. In this kind of work the food officials are upheld by all honest producers and merchants, who are always willing to describe truthfully the character of the goods in which they deal. Nor would it be expected to be otherwise.

The food industry itself should and does welcome as much or more than the consumer the enforcement of pure-food legislation. The very foundation and success of business have demanded strictest integrity in transactions among individuals and firms. The brands which have the widest sale have been established by years of square dealing with consumers. And when the food laws require all firms to deal honestly with the consumer, not only as a matter of principle, but as a matter of law, both as regards the label on the outside of the package and the product within, the results will bring a far-reaching benefit not only to the consumer but to every producer, manufacturer and dealer.

CARRYING COAL BY PIPE LINES

A MACHINE has been invented which is designed to mine coal in the granular or powdered state, mix it with water and then pump it through a pipe line to its destination. It will then be separated from the water and dried, and it can be used for almost all the purposes for which the lump coal is now employed.

According to the engineers who have designed this machine, it has proved by tests so economical in operation that they say it may change the whole art, not only of mining, but of transporting and consuming coal. The machine is automatic, it being advanced by a hydraulic feed mechanism.

The rotary cutters, which are not unlike a circular saw, are driven by an induction motor. The coal is pulverized by these cutters and washed into a nearby receptacle by a powerful stream of water. From this receptacle it is pumped to any desired point. L. E. M.

BACTERIA AND PROTOZOA*

WHAT THEY ARE, AND WHERE THEY BELONG IN WORLD OF LIFE — SOME DISTINCTIONS THAT CAN BE DRAWN BETWEEN THE TWO GROUPS OF MICROSCOPIC LIFE

BY F. SCHNEIDER, JR.

The most striking distinction that can be drawn between protozoa and bacteria is embodied in the statement that whereas the former are animal microbes, the latter fall among the plants. The members of both groups are true microbes,—"little living things," so small indeed as to be discernible only with the aid of a microscope. In both cases the microbes are unicellular, consisting of but a single cell or unit of living matter; thus representing the simplest form of organization known in the living world. Similarly, the organisms of both groups are naturally aquatic in habit, requiring moisture to best carry on their activities, and in both instances examples are found of the capacity for spontaneous movement. But while the two groups have these and other characteristics in common, it is generally agreed that the protozoa occupy the lowest and most elementary position in the animal kingdom while the bacteria hold a similar position among the plants.

This clear-cut distinction is supported by various supplementary differences. For one thing, the bacteria form a simpler and more compact group. They are neither so large nor so complicated in structure as the protozoa; nor do the members of the group exhibit as wide a divergence one from another in form. A good example of bacterial structure is the common hay bacillus. This organism, an inhabitant of the soil also commonly found in air and water, is a minute rod about one five thousandth of an inch in length and one twenty-five thousandth of an inch in diameter. Structurally it is a mere bit of living matter (or protoplasm) held in shape by a thin skin or membrane. The tiny cell is so minute that even with the most powerful microscope its internal structure remains a subject of conjecture. Under suitable conditions it can, however, be made out that the cell is covered with minute thread-like processes, which from their whip-like appearance have been termed flagella. It is by means of the flagella that the organism propels itself through the surrounding fluid. Under unfavorable conditions, such as of food supply or moisture, the hay bacillus can concentrate its protoplasm into a very dense ball, or spore. These spores are extremely resistant to heat and drying, but when normal environmental conditions are restored will germinate into the ordinary form. The reproductive process is of extreme simplicity; a constriction appears in the centre of the full-grown rod, deepens, and finally separates the two parts, which grow again to full size. The appearance of this organism is made clear in figure 1.

The same simplicity of structure is displayed by the other bacteria, although many cannot form spores, and many do not possess flagella and the accompanying power of free movement. Aside from the group of rod-shaped or bacillus forms, practically all the bacteria fall into two other classes, — spherical ones, or cocci (pronounced cock's eye), and spirally twisted ones, or spirilla. These forms are illustrated in figure 2. The structure is essentially the same, a simple bit of protoplasm surrounded by a delicate membrane.

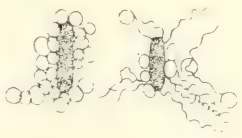


Figure 1. *The Hay Bacillus.* Some of the flagella have curled up in the drying process, preparatory to staining.

* Copyright, 1913, Society of Arts. All rights reserved.

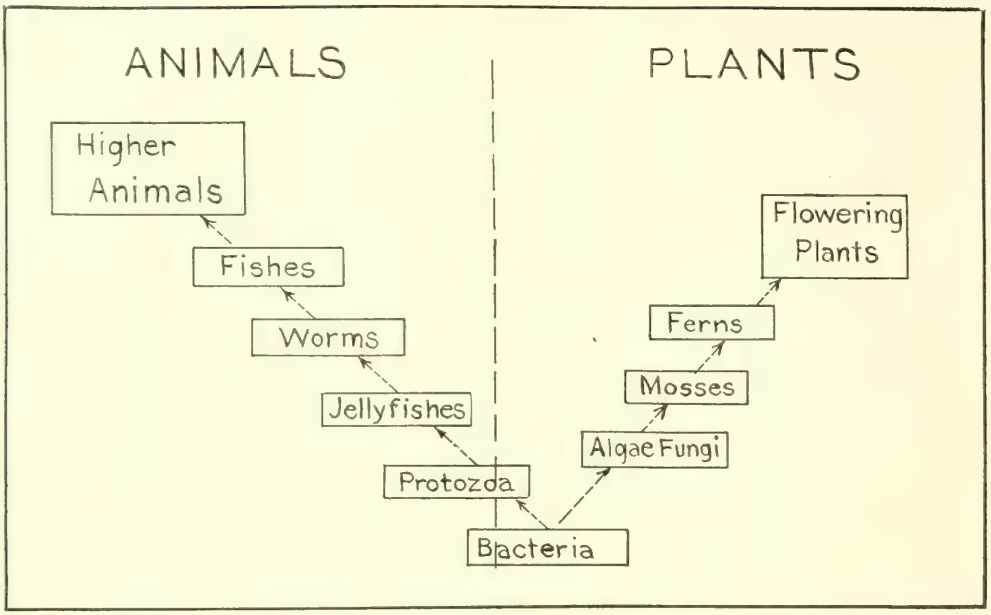


Figure 7. Relationship of Bacteria and Protozoa

When we now come to consider the protozoa we find that these animal forms are decidedly more complex. They are, still, like the bacteria, each a single cell, but the parts of the cell have become differentiated to special purposes. Even the simplest forms like the Amoeba, shown in figure 3, exhibit this differentiation. A constant component of the protozoan cell is the nucleus, a specialized part of the protoplasm, not present in the bacteria but always found in cells of the higher forms of life. The nucleus seems to have regulative powers over the cell, and to be particularly involved in the process of reproduction. Referring again to Amoeba we see that it contains certain clear spaces, or vacuoles. Some of these function in the absorption and digestion of food, while others serve in disposing of waste products. No external membrane is present in Amoeba; in motion the organism simply pours out its naked protoplasm in the line of movement and so rolls, as it were, over and over on itself. Reproduction is here similar to that of the bacteria, simple division into daughter cells which grow to full size and are then ready to repeat the process. Amoeba is much larger than the hay bacillus, being in diameter about one two hundredth of an inch.

Another representative protozoan is shown in figure 4. This organism, of about the same size as Amoeba, is found parasitic in the digestive tracts of certain marine animals. A well-marked nucleus is present, and one end of the cell is specially differentiated for adhering to the

Figure 2. Forms of Bacteria

wall of the alimentary canal. With this class of protozoa there appears, however, a complicated life-cycle or life-history. Certain processes set in, which result in the breaking up of the organism with the formation of considerable numbers of small spore-like bodies. These "sporozoites," when finally liberated, enter the wall of the alimentary canal at new points, undergo a developmental stage therein,

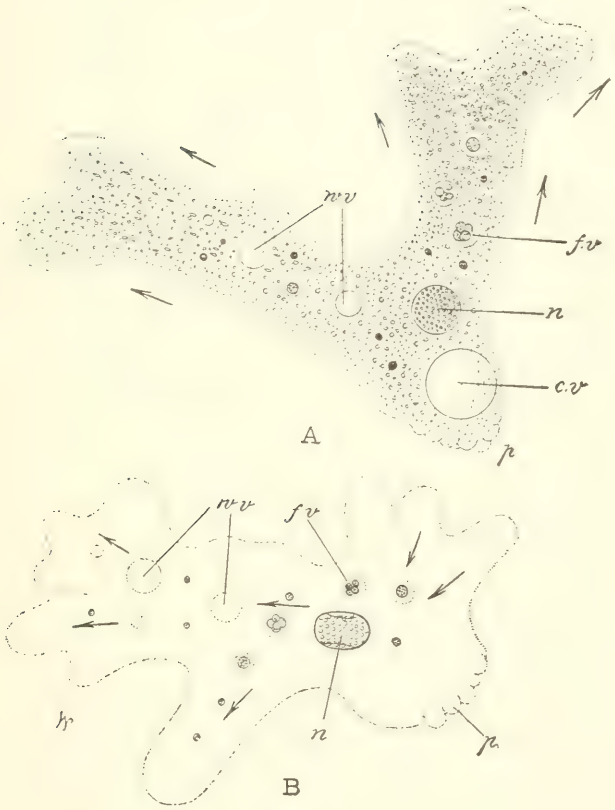


Figure 3

Amoeba Proteus,—from life, magnified 300 times. The arrows indicate the direction of the protoplasmic currents; *n*, nucleus; *c. v*, contractile vacuole; *f. v*, food-vacuole; *w. v*, water-vacuole. A shows the texture of the protoplasm. B is an outline of the same individual four minutes later; the upward currents at the right of Fig. A have stopped, reversed, and the main flow is now towards the left.

and finally emerge again into the intestine as the original attached form. Compared with the hay bacillus and Amoeba this is assuredly an involved life-cycle.

Euglena, typical of another group of the protozoa, is shown in figure 5. This organism is again of a size with Amoeba, and possesses a flagellum similar to those found among the bacteria. For an animal it has the surprising characteristic of possessing chlorophyl, the green coloring matter of plants. With its chlorophyl it can utilize sunlight, carbon-dioxide and water to form starch, distinctly a plant characteristic. The tiny red "eye spot," bordering on the contractile vacuole, is supposed to be sensitive to light. This microbe is free swimming by means of its flagellum, and is one of the most interesting and beautiful of all protozoa.

Figure 4

Trophozoite of *Lankesteria ascidiae* attached to an epithelial cell (ep'), which is withered and apparently destroyed by it, ep, normal epithelial cells.

We come finally to still another class of these organisms, characterized by the possession of many small lashing hairs —shorter and stiffer than flagella, and termed cilia. Paramoecium, the so-called "slipper" animalcule, which sometimes grows so large as to be discernible to the unaided eye, is a good example. Reference to figure 6 shows not only that this organism is thoroughly covered with fine cilia, but that it exhibits, for a single cell, a surprising amount of differentiation. A distinct gullet for the entrance of food is provided; there is a complicated system of vacuoles; waste products are expelled at a definite point; and there is even a separation and specialization of the nuclear material. The beginnings of a process of sexual reproduction are also illustrated. While the organism ordinarily reproduces by a simple transverse division analogous to that obtaining among the bacteria, it has been observed that under certain conditions two individuals will come into intimate contact and exchange nuclear material. This process is called conjugation, and forecasts the higher sexual process of union of specialized male and female elements. Experiments have been carried on to determine whether conjugation must alternate with the regular splitting division at definite intervals, but while some observers have found this to be seemingly the case, others have carried specimens through as many as two thousand successive divisions without a suggestion of a halt. The theory has accordingly been advanced that these organisms are in a sense immortal, never aging and never requiring the introduction of new elements to their protoplasm.

Sufficient has now been said to indicate that there are well-marked differences between the two great groups of microbes known as bacteria and protozoa. We have seen that as a group the protozoa exceed the bacteria in size, complexity, and variation of type. But we have also seen that some protozoa—as Euglena, possess characteristics generally recognized as distinctively vegetable. And, on the other hand, the bacteria possess important characteristics essentially animal. Evidently the matter is not as simple as would be signified by our original line of separation into animals and plants. And if we examine the matter closely we see that the three great criteria which are generally taken as distingushing plants from animals,—the possession of chlorophyl and the resulting simple food requirements, the cellulose cell wall, and the lack of movement in the plant body, are not met in the case of the bacteria. What then is the justification of our original distinction?

The answer to this question is found in a study of the relationships of the two groups to the other plants and animals. It is not a matter of applying to the forms under consideration clear-cut tests as to their animal or vegetable nature, but rather a matter of considering what other groups of organisms they most closely resemble. The bacteria, for example,

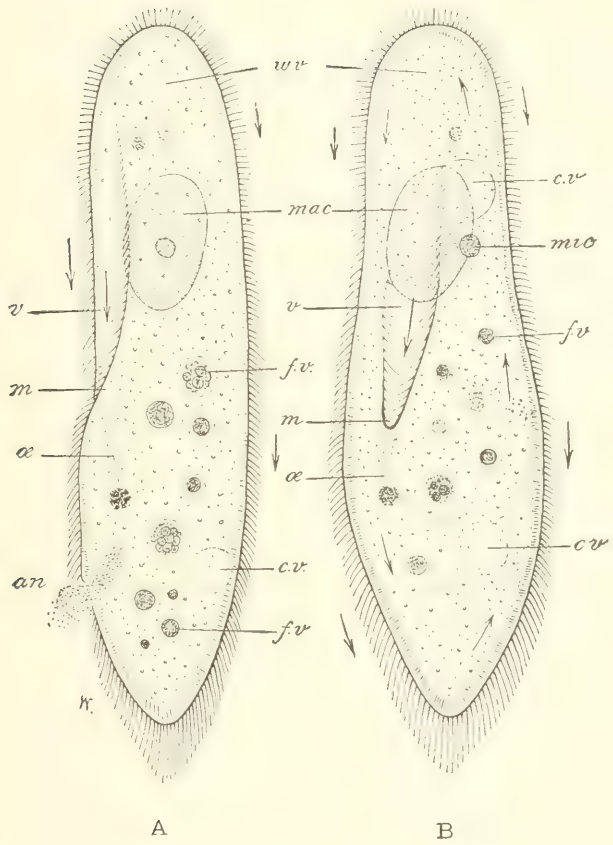


Figure 6

Paramoecium caudatum. A, from the left side, showing the anal spot; B, from the ventral side, showing the vestibule *en face;* arrows inside the body indicate the direction of protoplasmic currents, those outside the direction of water-currents caused by the cilia.

an, anal spot; *c. v.,* contractile vacuoles; *fv,* food vacuoles; *w. v,* water vacuoles; *m,* mouth; *mac,* macronucleus; *mic,* micronucleus; *oe,* oesophagus; *v,* vestibule. The anterior end is directed upwards.

despite several pronounced animal characteristics, seem to be linked closer to the blue-green algae, which are undoubted plants, than to any other group. Accordingly we are disposed to place them in the vegetable kingdom. The truth is that as we go lower in both kingdoms the

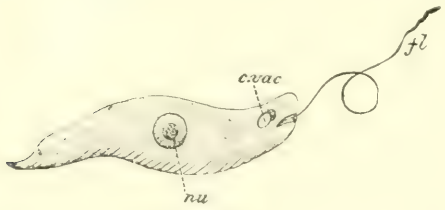


Figure 5

Euglena. *c. vac*, contractile vacuole; *nu*, nucleus; *fl*, flagellum

lines of descent finally converge into a region of general similarity and uncertainty. Haeckel, the great German zoologist, has even suggested that instead of recognizing two separate groups of animal and plant microbes, we should see them combined into one large group to which he would give the name protista, or first animals. This plan, though apparently offering simplicity, seems to disregard real distinctions, and to leave us still with the old problem of setting up boundary lines, now around the new group.

A good working understanding of the situation may be gained from an examination of Figure 7. The arrows show the lines of ascending relationship and evolution from the lower to the higher animals and plants. At the foot of the scale we have on one hand the protozoa, on the other the bacteria. Both these groups are shown as overlapping a little into the opposite kingdom, and the dotted line between them indicates their interrelation. We may conclude that these are our simplest forms of life, microscopic and unicellular; the protozoa, on the whole, seeming to be linked more closely with the animals, the bacteria with the plants.

WONDERFUL MOVING PICTURES

In an article on motion pictures in a recent number of *McClure's Magazine* the author states that Dr. Comandon, a French scientist, has already shown what the combination of microscope and moving-picture camera can achieve in physiology and bacteriology. For the first time, he has given the world a picture of the blood coursing through the veins. He has likewise photographed one of the greatest medical discoveries of the age—the action of the white corpuscles of the blood which is known as phagocytosis. The discovery of this phenomenon is the thing that will immortalize the name of Metchnikoff. Metchnikoff discovered that the white corpuscles protect the blood, and consequently the body, from injurious foreign substances. They are the body's scavengers, or guardsmen. If any foreign substance enters the body, these white corpuscles, or phagocytes (cell-eaters), as Metchnikoff calls them, at once surround and absorb it. Their chief function is to protect us against bacterial diseases. If typhoid germs get into the blood stream, the white corpuscles immediately begin devouring them. If they succeed, we escape the sickness; if they fail, then we are forced to take to our beds.

When Metchnikoff first announced this discovery, scientific men were skeptical, though now they generally accept it. If there are any doubters left, the moving-picture machine can satisfy them. For, on an enormously magnified scale, Dr. Comandon has shown the phenomenon of phagocytosis in actual operation. What Metchnikoff, in the course of a lifetime, painfully worked out with the microscope, appears on the screen with all the realism of a dog fight.

A patient and ingenious Englishman, Mr. F. Percy Smith, has performed similar marvels with plant and insect life. He has succeeded in producing a film that shows a flower developing from seed to blossom. One of his most popular achievements is a moving picture of a chicken hatching from the egg. An Italian has completely cinematographed the development of a butterfly from a caterpillar; he even filmed the supreme moment of its emergence from the chrysalis.

MOSQUITOES AND THEIR EXTERMINATION*

THE LIFE HISTORY OF MOSQUITOES AND THE METHODS OF SUCCESSFULLY WAGING A WAR OF EXTERMINATION AGAINST THEM

BY WILLIAM LYMAN UNDERWOOD

THE statement has been frequently made of late that there is no more reason why we should suffer from mosquitoes than there is that we should allow rats and mice to continually annoy us, and this statement is in a measure true. Rats and mice are to a great extent effectively held in check, for we have become accustomed to them and their habits, and we know how to deal with them. Were it not for the fact that a constant warfare is being waged against them, they would soon overrun our houses and make life unbearable.

In order to fight the mosquitoes successfully it is important that every one should take an interest in the popular uprising against this insect pest. And now that it is known that, besides being a nuisance, mosquitoes may be a menace to the health of the community, it is equally necessary that every one should become familiar with all that pertains to their life history so that the war against them may be successfully and intelligently carried on. Notwithstanding all that has been written on the subject of mosquitoes during the last year or two, the majority of people still know but little about them.

It is the purpose of this article to state, in as simple a manner as possible, the facts that are now known regarding mosquitoes and how to deal with these pests, and it is hoped that this information may help to secure a more general cooperation in the work of mosquito extermination.

Few people realize that there are a great many different kinds of mosquitoes. Some three hundred species have already been described, and here in the United States we have about fifty species, belonging to nine different genera. The most common of these genera in the northern states are *Anopheles*, the malarial, and *Culex*, the ordinary, mosquito. Of the former there are two species and of the latter at least fifteen.

Only these two genera and the methods for their extermination will be especially considered, and as these methods may also be successfully applied to the other kinds of mosquitoes, no detailed description of the others need be given.

It is commonly and quite naturally thought that mosquitoes breed in wet grass, as they are often seen to rise from it in clouds when disturbed, particularly in the early morning and evening. They have not bred there, however, but have merely sought the shelter of the grass where they can be protected from the wind. The moisture of the dew upon the grass also furnishes an attraction for them and they always prefer damp rather than dry places.

Another popular theory is that mosquitoes will breed *only* in foul or stagnant water. This is also a mistaken idea though they often do breed in such water, not because it is impure or stagnant, however, but because these places are usually quiet and here the female can deposit her eggs undisturbed.

It is commonly supposed that mosquitoes do not breed in salt water, but the "Mosquito Investigations" of Prof. John B. Smith of New Jersey, which were published in the New Jersey Agricultural College Experiment Station Report of November, 1902, show that the larvæ of *Culex sollicitans*, the "salt marsh mosquito," not only prefer salt or brackish

*Illustrated with photographs from life by the author. The illustrations and photographs are copyrighted.

Fig. 1. Mosquito "wigglers"—larvæ and pupæ—in the water. Life size

water, but are seldom found in pools where the water is strictly fresh, and, contrary to the usual custom, this mosquito lays its eggs upon the soil of marsh or meadow land. There the eggs remain until the advent of an unusually high tide. Then after a few hours when the water has covered them, the infant larvæ make their appearance.

It is very generally believed that mosquitoes bite but once and then die. This is sometimes so; but, unless they are killed in the act of biting, they usually live to bite again. The female mosquito (for it is only the female that attacks human beings) bites many times. It is owing to this fact that *Anopheles* is able to convey the germs of malarial fever from person to person. When biting any one who is afflicted with malaria, the insect draws in with the blood the germs of the disease, which it afterwards carries on into the blood of another victim. The vast majority of mosquitoes never get human blood for food. In its absence they live upon the blood of birds and other animals, and when these are not to be found, upon the juices of young and tender plants.

It is not known just how long mosquitoes can live, but their average life is much longer than is ordinarily supposed. Thousands of them live through winter hibernating or asleep in dark places in barns or house cellars. In sparsely settled localities, where they cannot find such places for shelter, they live through the winter in hollow trees, in caves and holes under upturned trees; and, even though the temperature may fall far below freezing, they are not winter-killed, but on the approach of warm weather become active again. Mosquitoes are frequently seen flying about in the woods before the snow has wholly left the ground.

Mosquitoes cannot develop or come to maturity without water in which to live during the first weeks of their "wiggler" existence.

A mosquito's life is divided into four stages—the egg, the larva, the pupa and the adult insect. In the larval and pupal stages, mosquitoes are more commonly known as "wigglers" (see fig. 1). Both

Anopheles, the malarial, and *Culex*, the common, mosquito larvæ are present in this picture. Mosquito "wigglers" may frequently be found in rain-water barrels in as large numbers as are seen in this photograph. The female mosquito lays from one hundred and fifty to four hundred eggs upon the surface of some quiet water, and in a day or two these eggs develop into the larval or second stage.

It will be noticed that *Culex* hangs with its head down, and from its tail upward to the surface of the water extends a small tube. Through this tube it breathes. *Anopheles* rests just beneath and parallel to the surface of the water, and its breathing tube is much shorter than that of *Culex*. These resting positions are quite different, and each is characteristic of its kind. Except when disturbed, *Anopheles* is generally to be found at the surface, breathing and feeding in this position. *Culex*, on the other hand, comes to the surface only occasionally to breathe. It stays below the water for the greater part of the time, and is often found feeding from the bottom.

At the end of a few days the larvæ change into the pupal or third stage (see fig. 2). To the left is seen the larval skin out of which this pupa has just come. The difference between *Culex* and *Anopheles* in this, the final stage of "wiggler" existence, is very slight. Both now live at the surface of the water, and they breathe through two funnel-shaped tubes situated one on each side of the thorax, or "head." Unless disturbed, they remain motionless in this position at the surface until the time comes when, as adult mosquitoes, they leave the water. This is the critical period of a mosquito's life; for, should the surface of the water be disturbed at this time, the insect would be upset and drowned. It takes about seven minutes from the time when the skin along the back of the pupa begins to split until the full-grown mosquito comes forth and in a few minutes is ready to fly away. A mosquito never grows any larger after this change.

The length of time required to pass from the egg to the adult insect varies from ten days to three weeks, according to the temperature. Warm weather hastens their development, while low temperature checks it. The "wigglers" of some species of mosquitoes live through the coldest weather of our northern winters unharmed, ready, when the first warm days of spring have come, to complete their natural changes.

Mosquitoes' eggs are so very small that ordinarily they remain unnoticed, but nearly every one who lives in the country is familiar with the little "wigglers" that are often seen squirming up and down in rain-water barrels. Few people know that these little fellows are connected in any way with mosquitoes, but it is a very easy matter to prove that they are. Let any one who doubts this fact dip up a few in a glass jar or tumbler and place them in the house, where they can be frequently looked at. Seeing is believing; and after a full-grown mosquito has once been seen to come forth from a pupa (which is the

Fig. 2. A pupa, the third stage in a mosquito's life. Three and one-half times as large as life

last stage of the "wiggler"), there can no longer be any question as to what these "wigglers" really are.

Most of the mosquitoes that annoy us are bred near by, often, though unknown to us, in our own dooryards. Any water that is accessible to mosquitoes and whose surface is undisturbed by winds or rapid currents furnishes a breeding-place for them, and "wigglers" may often be found in water standing in old

tin cans or bottles, in rain-water barrels, in pools in the rocks, in roof or street gutters that are not properly drained, in cesspools or in catch-basins, in fact, in any place that will hold water for a week or two, no matter how small the quantity, even if only a few teaspoonfuls.

Since we know that without water mosquitoes in their first stages cannot exist, it naturally follows that all standing water should be done away with or treated in such a manner that "wigglers" cannot live in it nor mosquitoes get to it to lay their eggs. To this end all cans, bottles, and every discarded utensil that will hold water should be removed. All stagnant pools, where it is possible to do so, should be drained or filled up. Cisterns, rain-water barrels and cesspools should be screened or otherwise covered to prevent the adult insects from having access to them. Where it is not practicable to fill, drain, or screen the places that are suitable for mosquitoes to breed in, the surface of the water may be covered with kerosene oil. This oil, when spread over the water, prevents the "wigglers" from getting air when they come to the surface to breathe, and so kills them (see figs. 3 and 4).

In figure 3, a "wiggler" is seen trying to get air, vainly thrusting its breathing tube up into the film of kerosene.

In figure 4, the upper "wiggler" is grasping its breathing tube in its mouth, apparently trying to pull off the small particles of kerosene with which the tube has been clogged. The "wigglers" upon the bottom have been suffocated and have given up the fight.

An ounce (two tablespoonfuls) of kerosene will spread over fifteen square feet of water surface, forming a film thick enough to kill all the "wigglers" that are beneath it. Kerosene of a cheap quality, known as high test light fuel oil, is preferable for this purpose. It can usually be bought at eight cents a gallon. If oil of this quality is not available, ordinary kerosene will answer the purpose. It should be applied as often as once in two weeks, for by that time the previous application will have evaporated. A sufficient quantity should be used, in the proportions named, to cover completely any place that may need treatment.

Any one who is ill with malaria or yellow fever should be carefully protected from mosquitoes, for, should a person be bitten by an *Anopheles*, the malarial mosquito, or *Stegomyia fasciata*, the yellow fever mosquito, at this time, there would be great danger that the insects might fly away and bite some one else and thus spread these diseases. Screens for both doors and windows form the best protection against mosquitoes at all

Fig. 3. Three times as large as life

times; but it often happens that the insects get into our houses, even though they are thoroughly screened, generally through some door or window that has been left open by mistake, or they may gain an entrance by coming down an unused chimney if the flue is allowed to remain open during the summer time. A house or a room may be cleared of mosquitoes by burning pyrethrum powder and allowing the smoke, which is not at all offensive to most people, thoroughly to fill the room that is under treatment. This smoke kills or so stupefies the insects that they will not bite. Pyrethrum powder is a preparation of the plant

Pyrethrum roseum, and is sometimes sold as Persian Insect Powder or Dalmatian Powder; it can be bought at any drug store for about thirty-five cents a pound.

Fig. 4. Three times as large as life

It is a very fine, light powder; and an ounce of it will go a long way, making a large volume of smoke. A pyrethrum smudge or smoke may be started by covering a live coal, taken from the kitchen stove, with the powder, first placing the coal upon a small shovel, so that it may be moved about conveniently without danger of setting anything on fire. The pyrethrum will quickly begin to smoulder and give off a dense smoke. All that is now necessary is to add from time to time a pinch of the powder as occasion requires, merely keeping the smouldering ashes covered so that they will give off a smoke. People are frequently annoyed and sometimes driven into their houses on summer evenings by the persistent attacks of mosquitoes. On such occasions, pyrethrum powder can often be used to advantage; and the smoke from a small quantity of the powder kept smouldering upon the piazza will drive away most, if not all, of the pests, thus making it possible to enjoy an evening out of doors in comfort, when otherwise life would be unbearable except behind the protection of screens.

The *Anopheles*, or malarial mosquitoes, though not very common (see figs. 5 and 6), are breeding quite abundantly in many parts of this country; and by referring to the accompanying photographs, particularly the ones in profile, it will be seen that there is quite a difference between the malarial and the common, or *Culex*, mosquitoes.

They may easily be distinguished from the common or *Culex* family of mosquitoes by the spots upon their wings, and also by the position which they take when at rest (see fig. 6).

Notice the angle at which the insect shown in figure 6 stands out from the wall. It will also be seen that the proboscis, or "stinger," and the body of *Anopheles* form a straight line, while the *Culex* is rather humpbacked. The other *Anopheles, maculipennis*, does not stand out from the wall at quite such an angle as does *punctipennis;* but like the latter its proboscis and body form a straight line, and the angle formed by the insect when at rest is much greater than that of the *Culex*.

Fig. 5. *Anopheles punctipennis* (female). Three times as large as life

The male mosquito never bites. He may be easily distinguished by his large and feathered antennæ and palpi, which are very much more prominent than those of the female.

There is another mosquito, *Stegomyia fasciata*, which in form and habits closely

Fig. 6. Profile of *Anopheles punctipennis* (female). Six times as large as life. Showing the characteristic resting position of this mosquito.

resembles *Culex*, in which genus, until quite recently, it was classed. *Stegomyia fasciata* is the yellow fever mosquito, and it inhabits only the warmer portions of this country. It is common in most of our southern states and is seldom seen north of the Carolinas. It is easily distinguished from other mosquitoes by the conspicuous silvery white stripes upon its thorax and abdomen, and by the white bands upon its legs.

Fortunately for mankind, nature herself provides many energetic workers which are constantly doing their part towards holding in check these insect pests. Foremost among these natural enemies are many of the insectivorous birds, which daily destroy many thousands of mosquitoes. The swallows, the fly-catchers, the night-hawks and the whip-poor-wills, all are insect exterminators, whose good work in this connection is seldom taken into account. The bat is also an efficient mosquito hunter; so, too, are the dragon flies which frequent the shores of ponds and pools where mosquitoes breed.

Besides these enemies of the adult mosquito, which may properly be called their "foes of the air," mosquitoes have other adversaries which destroy them in their early stages. These may be termed their "foes of the water."

It often happens that we can find no "wigglers" in small ponds in which we would naturally expect to find mosquitoes breeding. In such ponds the presence of fish may account for the absence of mosquitoes. Their larvæ furnish food for many species of our smaller fishes, and by them myriads of mosquitoes are annually destroyed. Goldfish are particularly fond of mosquito "wigglers," and the pair of fish in the illustration (see fig. 7) were seen to eat ninety-eight "wigglers" in four minutes. Goldfish will live and multiply in almost any small and shallow pond in this vicinity, where the water is warm. They are perfectly hardy and will thrive just as well and perhaps better in stagnant water than they will in flowing streams.

The "top minnow," the roach, the sunfish or "pumpkin seed" and even the sluggish horn-pout all play an important part in reducing the numbers of mosquito "wigglers." Besides the fishes, there are other "foes of the water" that prey upon mosquito larvæ. Many of the predatory water bugs feed upon them. Prof. J. B. Smith, in the report previously referred to, says that "among these predatory insects which abound in shallow permanent bodies of water wherever

Fig. 7. Goldfish eating mosquito larvæ. Life size. These two fish were seen to eat ninety-eight "wigglers" in four minutes. They always fed upon mosquito larvæ when they could get them in preference to prepared goldfish food

there is vegetation, the water boatman (*Corisa* and *Notonecta*), the water striders or skate bugs (*Hydrobatidæ*) and the water scorpions (*Nepidæ*, *Belostomatidæ*) deserve mention." He also speaks of the "water tiger," the larva of the large water beetle (*Dytiscus*), and tells of its ability to clear *Culex* larvæ from pools of water.

In this connection a brief description of a newly discovered mosquito,* to which has been given the name *Eucorethra underwoodi*, should be of interest, since it has been found that their larvæ devour the wigglers of other mosquitoes, and unlike other mosquitoes, the adult female insect does not bite. As the proboscis of this insect is so formed that it cannot puncture the skin, it should not perhaps be called a true mosquito, though it has been classed as one, since it belongs to the family Culicidæ.

The larvæ of this insect were found by the author in the Maine woods in the eastern section of Penobscot County, and were discovered in a spring of water from which a crew of lumbermen were getting their water supply. A few days later, other larvæ of the same species were found in a similar spring about eight miles distant, though in this case, as the spring was not in use, its surface was covered with a coating of ice an inch thick. The temperature of the water at the bottom (it was about two feet deep) was 42° F.

At first sight this larva would be taken for an *Anopheles* of extraordinary size, as it is of the same general shape, and when the water was cleared of ice, it lay just beneath and parallel to the surface, breathing through a short respiratory

*Under the title "A New Mosquito" a description of this mosquito appeared in *Science*, New Series, Vol. XVIII., No. 449.

siphon, as is characteristic of the larvæ of *Anopheles*. In this spring a barrel had been sunk and in the fifty gallons, or thereabouts, of water which it contained there were twenty-five larvæ. They were all of about the same size—12 to 14 mm. long—and almost black in color. All were secured and taken into camp for further investigation.

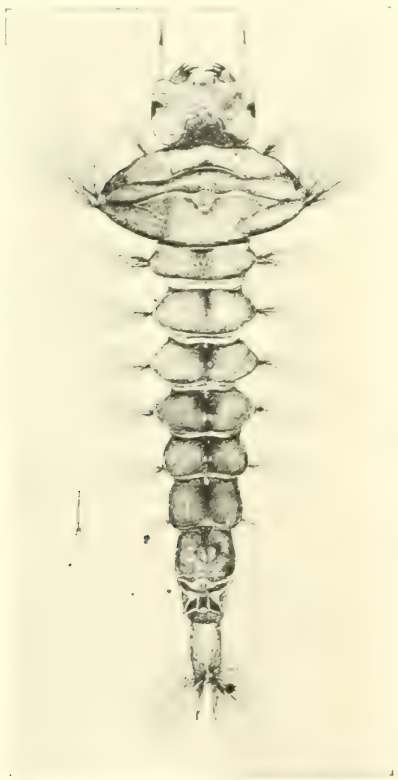


Fig. 8. Larva *Eucorethra underwoodi*. Dorsal view

Close observation of the larvæ showed that besides being much larger (12–14 mm. long instead of 5–7 mm.) they differed in many other particulars from the larvæ of *Anopheles* (see fig. 8). In proportion to the rest of its body, its head is larger than the head of *Anopheles*. It does not turn its head upside down when feeding as does *Anopheles*. Its mandibles are strikingly large and powerful and are prominently toothed. It lacks the frontal tufts or brushes which are conspicuously present in *Anopheles*, and its antennæ, which extend directly forward parallel with the sides of the head, are much longer and more slender, and are tipped each with three hairs of equal size. The thorax is broadly elliptical and is much wider in comparison with its abdominal segments than is the thorax of *Anopheles*. The sides of the thorax and the abdominal segments bear fan-shaped tufts of hairs, not plumosed as in *Anopheles*. The tufts on the last segments, both dorsal and ventral are more profuse in *Eucorethra* than in *Anopheles*, especially the ventral tuft which in *Eucorethra* occupies nearly the whole segment. Only two anal papillæ are present, while *Anopheles* has four.

A few days before the author returned to Boston, several larvæ died and three changed to pupæ. The pupa resembles that of *Culex* rather than of *Anopheles* and its respiratory siphons are of the same shape as those of *Culex*. When stretched out at full length, the pupa measures ten mm.

On reaching home, the new wigglers, eighteen in number, were put into a quart jar which was placed near a window where it would receive the sunlight for two hours each morning. The temperature of the water now averaged about 70° F., and with this change the larvæ developed a new trait—they began to eat each other up. The act was witnessed on several occasions. The larva would grasp its adversary just forward of the respiratory siphon with its powerful mouth parts, and working the tail in first it would gradually swallow its victim, shaking it now and then as a terrier would shake a rat.

After losing many of the insects in this way, those that remained were separated, and each individual was placed in a small bottle by itself. Eventually, I succeeded in rearing a number of males and females. The pupal stage of this insect varies from five days and nine hours to six days and the hours. The adult (see fig. 9) resembles *Anopheles* in having maculated or spotted wings, but is much larger and measures

eleven millimeters in length. Its mouth parts, however, are not adapted for biting. A full description of the imago is soon to be recorded by Mr. D. W. Coquillett, of the National Museum, by whom the name above mentioned was given.

During a later visit to Maine, a large number of larvæ of *Eucorethra* were taken from the spring where the barrel had been sunk. It was noticeable that

Fig. 9. *Eucorethra underwoodi*. Coquillett MS. Original drawing

larvæ of other kinds of mosquitoes were absent, although the adults were very numerous in the immediate vicinity.

The absence of other mosquito larvæ was accounted for when later it was discovered that the larvæ of *Eucorethra* fed upon the larvæ of other mosquitoes, eating them apparently with great relish. On several occasions fourteen *Eucorethra* larvæ ate, during the night, sixty *Culex* larvæ out of the seventy that had been placed in the water with them. When eating the larvæ of mosquitoes smaller than themselves, the victim is caught, shaken violently a few times, and swallowed in a few seconds in very much the same way that a pickerel would catch and swallow a smaller fish.

Although myriads of mosquitoes are destroyed by the natural enemies which have been mentioned, man should be the most destructive foe of these insects. There is no doubt that the mosquito pest may be very largely abated by the employment of scientific methods for causing its destruction in the early stages of its development.

While it is the duty of boards of health to recognize mosquitoes as active agencies for the dissemination of certain diseases and to take such measures as are possible for their extermination, the work can never be effectively done until the people of each community are fully informed in regard to the life history of the mosquito so that all may cooperate ntelligently to secure its destruction.

A NEW METHOD OF PLATING

The Marino plating process permits electrodeposits on china and other nonconductors. The article to be plated, say, a china teapot, has its surface roughened by a sand blast and is then painted with a paste consisting of a mixture of the chloride, or other salt, of the metal to be deposited and hydorfluoric acid. This forms a preparative surface on which metal can be deposited from an electrolytic bath by the usual means. A thick plate of metal is obtained, which can be polished and worked, while at the same time the china interior is strengthened. This arrangement, it is claimed, also makes the cold galvanizing of such articles as screws, chains and other machine parts possible at a less cost than the present process.

THE ELEMENTS OF FATIGUE

THE RELATIVE SHARE OF MUSCULAR AND NERVOUS ELEMENTS IN ITS PRODUCTION. —A NEW EMPHASIS UPON SENSORY FACTORS IN ITS DEVELOPMENT.

BY PERCY G. STILES

No fact of life is more familiar than the development of fatigue. We anticipate that the vigorous and continued employment of a set of muscles will lead to sensations of discomfort, then of difficult effort, and, finally, of utter inability to continue the action. We expect to see parallel objective conditions: progressive loss of speed, force, and certainty of movement. The physiological changes which attend this decline of efficiency are far more complex than would at first be assumed. To enumerate them and to assign to each its proportionate share of the total effect has been a fascinating task and it is one which has not yet been completed.

The evolution of energy by a contracting muscle is limited by the store of available fuel. This is as strictly true for the living tissue as for a locomotive. In some respects the muscle is more like a machine-gun with a definite supply of cartridges. Either analogy is quite faulty but if we rely on such comparisons provisionally we shall be inclined to infer that fatigue indicates a dwindling stock of fuel or ammunition. We must not forget, however, that in the normal body fresh supplies are offered to the working organs by the passing blood-stream. Exhaustion is postponed accordingly and may not threaten at all if the degree of activity is moderate. Our best illustration of such renewal is found in the heart; the diaphragm approximates the same condition since it probably never fails to bear a part in the inspiratory movements.

Consumption of fuel in living or lifeless surroundings is attended with the generation of oxidized products. If such compounds are not promptly removed they will impede the fundamental chemical reactions of the contracting muscle. Fatigue, then, may be brought on by inadequate removal of wastes as well as by a shortage of energetic material. It becomes evident that an abundant circulation increases muscular endurance not only by providing fresh fuel but by dispersing the end-products—and perhaps the by-products—of the decomposition process. In fact it is commonly held that the failure of contraction usually occurs as a result of an accumulation of such substances and becomes absolute while much fuel yet remains in the cells. This conception makes fatigue an intoxication rather than an exhaustion and is in accord with the experience that fatigue of certain muscles spreads somewhat to others not used.

Laboratory experiments are easily devised which shall single out for observation the facts of true, localized muscular fatigue. In life the mechanism at work includes nervous as well as muscular elements and we have to consider the possible susceptibility of the former as well as the latter to the depressing consequences of their own activity. The resistance to fatigue exhibited by a man performing voluntary movements is not necessarily a measure of his muscular resources; it may be limited by conditions arising in his nervous system. It is of the utmost interest to discover the weakest link in the chain employed. We cannot make much progress in this direction until we shall have pictured the related parts which constitute a simple neuro-muscular mechanism.

A muscle is composed of a host of associated fibres of microscopic diameter. Each of these may be regarded as a muscle in miniature. It is a thread-like af-

fair averaging an inch or more in length. About midway between its extremities it is tapped by a filament derived from the nerve governing the muscle in question. The muscle-fibre is a chemical engine; the function of the connected nerve-fibre is to throw it into action. One is reminded of the electric wires by which a torpedo is exploded. Where the nerve-substance seems to blend with that of the contractile muscle-protoplasm there appears to be an intervening structure differing from either. This junction is referred to as the motor end-plate.

If we could trace the course of a selected nerve-fibre back from an end-plate to its place of origin we should be led within the confines of the central nervous system. If the fibre were one which terminated in a leg muscle it would be found to spring from a curiously branched cell in the gray matter of the spinal cord. The same would be true of a fibre terminating in the arm but in this case the cord-cell would be higher up. The muscles of the head are presided over by cells in the brain. Still retaining the crude analogy of the torpedo and its connections we find the nerve-cell standing for the battery which generates the current used to bring about the explosion. Under the terms of this comparison the end-plate is a priming appliance to transmit the effect of the nerve impulse to the unstable substance of the muscle. Any such attempt to compare the living fabric with artificial systems does violence to detail and must be regarded as symbolic rather than literal in character.

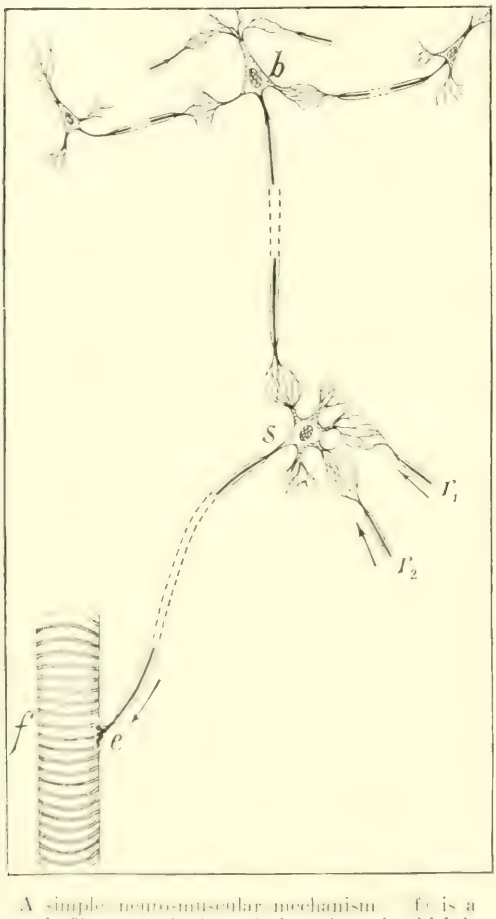
In the light of what has been said it will appear that fatigue may conceivably result (a) from changes in the working muscle, (b) from declining efficiency of the end-plate, (c) from alterations in the nerve-fibre, (d) from the decomposition processes in the nerve-cell. One of these theoretical possibilities may be ruled out. This is (c) in the series above; there is no doubt that of the several elements the nerve-fibre is the least subject to fatigue. Among the others it is commonly held that the end-plate is particularly liable to deterioration and that it is the diminishing utility of this transmitter which practically cripples a muscle after a certain period of vigorous use. It has been suggested that the end-plate bears a degree of resemblance to the safety fuse so often introduced in connection with electrical fixtures. This is to say that injury resulting from over-stimulation may be expected to fall upon this structure (which may be supposed to be easily renewed) and not to affect so readily the elaborately organized protoplasm of the muscle-fibre or the nerve-cell.

Most discussions of the subject of fatigue have been limited to the elementary mechanism just sketched. But when we are dealing with the intact organism and not with laboratory preparations there are additional matters to be considered. The nerve-cell which is the immediate source of excitation is not self-stimulated. The responsibility for its discharges is to be referred back to the activity of other cells so placed as to play upon it. In the case of those contractions which we regard as voluntary the cord-cells are known to be spurred to their work by cerebral cells. As soon as we include this new order of nervous units we find that we have to recognize further possibilities in the distribution of fatigue. We are called upon not only to estimate the extent to which true brain fatigue may figure in the observed result but to ascertain also whether the point of functional union between one nervous element and another may become impaired for its work as may the end-plate between nerve and muscle.

The "point of functional union" just mentioned is covered by the convenient word "synapse." The fact has lately been established that the synapse has to be reckoned with in any full treatment of the incidence of fatigue. It is very probably a link of inferior endurance and by its early refusal to conduct stimuli it may be assumed to protect the adjacent cells from excessive wear and tear. The symbol of the safety fuse is at least as legitimate for the synapse as for the end-plate.

We have traced the causation of voluntary muscular movement back from the muscle to the motor nerve-cells di-

rectly in connection with it and thence to cells of higher position in the nervous system. It is found to be difficult to account for the activity of these higher



A simple neuro-muscular mechanism. (f) is a muscle-fibre. (e) is the end-plate through which it is stimulated. (s) is the motor cell in the spinal cord which sends out the impulse. This cell is subject to excitation or perhaps to restraint through its several synapses. Of these three are shown fully developed; I_1 and I_2 are paths of approach for sensory impulses such as Forbes employed, the remaining path is from the cerebral cell (b). The efficiency of this brain-cell in typical 'voluntary' action is probably dependent upon the number of sources from which it is stimulated. Four of these are represented.

cells save on the assumption that they in their turn are goaded through synapses that place them in relation with still other working units in the brain. Whither are we led when we pursue as far as possible this shifting of responsibility for stimulation? Most authorities are agreed that we are obliged, in the last analysis, to conclude that the primary cause of the serial process is found in the influence of external conditions upon the receptors or sense-organs of the body. This is equivalent to saying that all muscular activity partakes very largely of the nature of reflex action. The psychological difficulties entailed cannot be dealt with here.

The emphasis lately placed upon the importance of the sensory side for efficient muscular performance has led to the question whether fatigue may not, in common experience, be due to changes on the route of the in-flowing as well as the out-flowing impulses which traverse the nervous system. We are compelled often to acknowledge that our fatigue is more accurately to be described as *disinclination* than as *incapacity*. To confess this is to express the belief that the motor mechanism still has power to work but that the sensory accompaniments have taken on a deterrent instead of a reinforcing character. We may conceive that the motor cells either in the brain or the cord—perhaps in both—are simultaneously prodded and restrained by different currents. The restraining or, technically, inhibitory influences become stronger with continued work while the positive stimulation is likely to flag.

Fatigue, when due to the fact that the inhibitory effect has become quite equal to the stimulation, will evidently disappear in part if new currents of an exciting sort can be supplied from without. This is exemplified by the power of emotional appeals, especially threats, to urge on a weary runner. Even more obviously it is the basis of the effect of blows. Yet the same principle may be recognized when the affective tone of the extra sensory application is wholly pleasant: for instance, in the postponement of fatigue for dancers whose whole environment encourages continued activity.

A reference in conclusion to a specific research will give coherence to much that has been said above. Alexander Forbes has shown (in cats) the following facts.[1]

[1] American Journal of Physiology, 1912, XXXI, 102.

A certain muscle is chosen for study and two sensory nerves are found, either of which can be employed to secure a reflex contraction of the muscle. One of these is stimulated persistently until the reflex fails. Stimulation applied to the other sensory path, immediately after, produces a vigorous reflex. What seemed to be total exhaustion is shown to be merely a failure of one particular inward route. Forbes locates the fatigue in his experiments in certain synapses between sensory and motor units of the spinal cord. He has simplified the conditions of his trials by eliminating the brain entirely and observing reflexes which are mediated through the cord alone.

Let us consider in what respects the human system is different at the end of a long day's walk from what it was in the morning. It doubtless presents many peculiarities which we have not hinted at. Altered secretory activities have influenced the composition of the blood; there has been an increase of lymph in many regions. The heart has been characteristically modified in its action. Without attempting to suggest other features we may summarize those which we have been discussing. The muscles contain less available fuel than they did. They are narcotized to some extent by their own chemical products. These products have been spread through the circulation and are very likely acting as depressants within the nervous system. The end-plates have suffered particularly and transmit with difficulty the impulses sent from the cord.

Fixing our attention upon the central axis itself we find that cellular fatigue there is a possibility but that exhausted synapses are more likely to be to blame for the sluggish reactions witnessed. Hence, to call out the last reserve of power, new means of sensory stimulation must be brought to bear. If our imagined subject is a tired soldier he may be carried along for a time under the sway of martial music. When that agency fails because its avenue of approach to the motor centers is choked, a pistol held to the head may compel him to continue his painful progress still longer. It becomes clear that if our fatigue were wholly a motor impairment, no fresh incentive to resist it could help at all. A playful trial of endurance would establish the same record as a struggle to escape impending death.

NOTE — One qualification may be necessary. The extensive nervous processes which accompany emotion may cause the extra formation of adrenalin and perhaps direct the metabolism in other ways to favor muscular performance. But this does not invalidate the truth that changes in the form of sensory stimulation may reveal stores of strength where apparent exhaustion prevailed.

FUTURE POWER AND HEAT

AN EDITORIAL writer in the *Electrical World* predicts that the transportation of fuel is soon to cease and the transmission of electric power will take its place, and that the future maps of industrial lands will be covered with a net work of transmission lines which branch out from sources of power either situated at waterfalls or at coal mines.

The transmission of electric power has certainly changed industrial conditions in many countries, especially the Alpine ones of Europe, which are tending towards industrial pursuits now that the utilization of their numerous waterfalls to give electric power is possible.

It does not, however, seem likely that electricity would be used to any great extent in the heating of houses on account of its inefficiency, but the future will probably see the abolition of the domestic heating plant and the substitution of central stations which will distribute heat by means of pipes in the form of steam; in all probabilities, superheated. L. E. M.

A calculation has been made of the time that elapses before a drop of water evaporated on the surface returns to the ocean. The total volume of water brought annually to the sea is 1-3460 of the total contents of the ocean. A particle of water before evaporation has stayed in the ocean on an average 3460 years. Once evaporated, the drop becomes condensed in about ten days and is then speedily drawn back to its ancient home.

SOME INDUSTRIAL USES OF SUGAR

MANY IMPORTANT USES FOR SUGAR FOR OTHER THAN FOOD PURPOSES GREAT DIVERSITY OF MANUFACTURES INTO WHICH IT ENTERS

BY GEORGE W. ROLFE

SUGAR, using the term quite in the popular sense, meaning what the grocer calls sugar—is of enormous importance to mankind as food, its annual consumption of some 17,000,000 long tons is enough to give every inhabitant of the earth at least 20 lbs. Hence, the attention of most people is diverted from the numerous uses of this substance in many large industries, by no means alimentary.

M. Vivien has given a most informing paper on this subject in recent numbers of the "Bulletin de l'Association des Chimistes de Sucrérie et de Distillerie de France et des Colonies," the leading French sugar periodical. Vivien writes with special reference to conditions in France, his paper being a plea for the use of sugar as the cheapest form of a chemically pure carbohydrate, replacing in many cases glucose, starch and dextrin.

The French Government imposes an internal revenue tax on sugar and glucose products used as human food which makes the price of sugar about 12 cents per pound, but by a law similar to that which applies to alcohol in this country "denatured" sugar, that is, sugar to which some substance has been added to make it unfit for food, is exempt from taxation. As in alcohol denaturizing, the substance added is, if possible, some ingredient in the special process using the sugar.

In France, an excellent quality of sugar known as No. 3 white sugar and polarizing over 99 per cent. sells, when denatured, at a price equivalent to from 3 to 4 cents a pound, or about what the refiners pay here for raw sugar. This is lower than starch, glucose or dextrin sells in Europe.

It may be of interest to note some of the more important applications of this denatured sugar, bearing in mind that in this country at present market conditions molasses and starch products are more economical substitutes in some cases. Some of the industries which Vivien enumerates are large consumers of sugar in this country.

Sugar is a common ingredient of many compounds for removing and preventing boiler-scale. As these usually contain alkali, this is used as a denaturant. The shoe-blacking industry uses sugar and molasses to considerable extent. In Europe there seems to be a tendency to use blackings of this older type as less injurious to leather than the newer wax blackings, owing to the solvents used in the latter. These shoe-blackings are made by the carbonizing action of sulphuric acid on the sugar. The product is neutralized and other ingredients, added such as powdered boneblack, oil, ink, and sometimes glycerine.

Perhaps one of the industries of greatest present importance, both here and in France, is the manufacture of transparent soap. Originally, the English soaps were made by the costly process of dissolving the soap in alcohol, decanting the soap solution and recovering the alcohol by distillation. Later, glycerine was used as a solvent but this made the soap too sticky, so that it soiled the wrappers. The sugar soaps do not have this disadvantage. Hence, many tons of sugar are now used by soap manufacturers in this country as well as in Europe.

There are over thirty patents for explosives in which sugar is a component to the extent of from six to forty per cent. This use of sugar has been so important

in Germany that a special provision is made by that country for denaturizing sugar used in the manufacture of explosives, paraffine or similar oil being used.

In the color and dyeing industries, we find sugar used as a reducing agent in indigo and chrome work, as a base for the manufacture of organic chromium salts and as a vehicle or "filler" for solid aniline colors giving them an attractive appearance. In many cases this latter practice is carried to somewhat questionable lengths as some of these dyes contain over 90 per cent. of sugar.

So too, the European tanneries use large amounts of sugar in "filling" leather, (glucose being used in this country) and to some extent, in removing lime from hides in the "dehairing." This solvent action of sugar on lime and the easy recovery of the sugar by carbonation has suggested its use in several processes where it is desirable to remove excess of caustic lime from calcined minerals, such as phosphates, zinc or magnesium oxides and the like.

Tannin extracts are also "filled" with sugar, as they are on this side of the water, with glucose. Sugar is also used in several chrome tanning processes as a reducer and, as in dyeing, for making acetates and formiates.

Ordinary copying ink is made by the addition of 1 part of sugar to 3 parts of writing ink. Printer's rolls and hektograph pads are made from glue combined with sugar or molasses. The silvering of glass mirrors is another important industry in Europe. Sugar, after inversion with acids, is here used to reduce an ammoniacal solution of silver nitrate which deposits a coating of silver on the glass immersed in the solution.

The hardening and strengthening action of sugar in mortar was known to the ancients in the far east and it is said that the Romans also made use of saccharine solutions for this purpose although sugar, known as "Indian Salt," was rarely seen in the Empire. Some of this ancient masonry containing sugar still stands in good condition.

In recent times, the Museum of Natural History in Berlin has been rebuilt with mortar consisting of 1 part of lime, 1 part of sand and 2 parts of sugar. Sugar is also used for hardening plaster moulds.

In many chemical operations, sugar is used as a source of carbon of high purity such as in the manufacture of pure carbon monoxide or sulphurous acid. As to future application it is possible that sugar may become of great industrial importance through its nitro compounds. Nitro-saccharose (sucrose octonitrate) is a product analagous to gun-cotton which, it is said, can replace the latter in its numerous applications in explosives, collodion, celluloid and the like. Similarly, it is claimed, sucrose acetate can take the place of the corresponding cellulose compound in viscose and artificial silk.

Certain compounds of sugar and benzoic acid also show promise in this direction.

This list of industrial applications of sugar is by no means exhaustive but perhaps suffices to illustrate the great diversity of manufactures in which this product appears quite apart from food economy.

SAFETY OF STEEL RAILS

In the testimony which President Farrell of the United States Steel Corporation gave before the Stanley Committee, he declared that the steel rails now produced are unsafe, stating that the high carbon steel now required is a source of danger, and that a soft metal would be far better, as far as the safety of the track is concerned. The liability to breakage is much greater than in the old-time soft steel rail, and the unavoidable contingencies of manufacture, such as seams, pipes and segregations, are more likely to be present.

This statement is in line with the growing opinion among most metallurgists. High carbon steel has been employed to obtain the stiffness necessary for an easy-riding roadway, but recent accidents have set experts wondering whether the loading of the rails has not gone beyond the maximum necessary for safety.

THE SOCIETY OF ARTS OF THE MASSACHUSETTS INSTITUTE OF TECHNOLOGY

The Society of Arts was established as a department of the Institute by President Rogers in 1861. It is especially devoted to the general dissemination of scientific knowledge, and it aims to awaken and maintain an interest in the recent advances and practical application of the sciences.

Any person interested in the aims of the Society is eligible to membership.

The annual dues are $3.

RICHARD C. MACLAURIN, President of the Institute.
ISAAC W. LITCHFIELD, Secretary of the Society of Arts.

EXECUTIVE COMMITTEE

THE PRESIDENT
ELIHU THOMSON
JAMES P. MUNROE
THEODORE N. VAIL
ARTHUR D. LITTLE
FREDERIC H. FAY

THE SECRETARY

BOARD OF PUBLICATION

D. F. COMSTOCK
SELSKAR M. GUNN
ELLWOOD B. SPEAR
LEWIS E. MOORE

I. W. LITCHFIELD, Editor

Science Conspectus is published December, January, February, March and April.

OIL BLOCKS FOR MARINE FUEL

During recent years the attention of marine engineers has been devoted to the methods of using oil for the purpose of making steam in the boilers of ships, but although many forms of spray fuel burners have been devised, a very serious obstacle appeared in the changing of existing apparatus which would be necessitated by the use of the new fuel. Devices for loading the combustible would have to be changed, immense tanks would be needed for the oil, and the action of the oil in the tanks would be felt when the ship was rolling.

At a recent meeting of shipowners in London there was a full discussion of the matter and it was decided to advance the idea of solidified petroleum brickets. These brickets are very simply produced, being made of boiled crude oil to which is added stearic acid with an alcoholic solution of caustic soda. The cooled solid is a transparent mass having sufficient cohesion to be shaped. The brickets are easy to handle, have a slow and regular combustion, are not affected by the weather, and pound for pound, are two and a half times as effective as coal. They would save a large amount of space on shipboard, it being estimated that on a single trip of a Cunard liner from England to New York and return, the lowest figure of saving would be $60,000. The solid oil could be handled by the present loading fuel apparatus with little modification and storage facilities would hardly have to be changed. One of the important features of course is that the range of the vessel would be very much increased, an important point in war vessels.

ACTION OF SHRIMP ON TIN

The popular idea that only acid substances attack tin is wrong, says the *Scientific American*. Fish, asparagus, beans, pumpkin and spinach are not acid and yet their corrosion of tin is quite marked. This is probably due to amino compounds, substances related to ammonia. In the case of shrimp, the cans are often eaten through in a comparatively short time. So alkaline is the methylamine contained in the shrimp that workmen in the canneries find the skin peeling off their hands and their shoes eaten through. Shrewd observation by some canners led to the discovery that if the shrimp were iced for a day before canning the corrosive action of the juices was greatly diminished. This is now the universal practice. In addition the cans are lined with paper to prevent contact of shrimp and tin.

SCIENCE CONSPECTUS

VOL. III FEBRUARY, 1913 No. 3

THE IMPORTANCE OF NEGATIVE EUGENICS

HOW FAR MAY WE GO TO ERADICATE A PERSISTING TAINT WHICH IS RESPONSIBLE FOR BETWEEN TWO AND THREE PER CENT. OF THE OBVIOUSLY UNFIT.

BY WOODS HUTCHINSON

EUGENICS is the art of the intelligent selection of our own parents. Unfortunately, most of us were not consulted as we should like to have been, about that matter, but we can see that the next generation is to some degree consulted. The problem of the method of preventing some of the unfortunate results which we see about us on every hand is one of the most vital and important things that confront us, not merely as sanitarians, but as humanitarians and as lovers of our kind. In the beginning, as most of you are aware, the direction taken by the eugenic movement, started under the brilliant and able leadership of Sir Francis Galton, was toward careful promoting of the mating and reproduction of the especially and peculiarly fit. That raised the question as to who should decide who were the specially and peculiarly fit, who were to be endowed and bowed down to by the rest of the community, and, not unnaturally, those, who first began this movement, selected their own class as the class that ought to be so endowed. And from that point of view, eugenics began. There were to be special classes of individuals and careful study was made, statistical study, if you please, showing how much more valuable, how many times more valuable to the community the child of a professional man or a well-to-do merchant was than the child of a day laborer, and how much more valuable still was the child of one of our great families. That was the principle on which the plan of campaign was to be conducted, but as soon as that began to be worked upon, we were faced with many objections.

In the first place, we found that while we would like very much to promote the reproduction of the fit, none of us knew enough to determine accurately who were the fit and who would reproduce the highest type of the future individual. We don't know what the future man is going to be like. Mr. Bernard Shaw thinks he knows, but he is the only man who has even ventured to express an opinion in that regard. We don't know what to breed to. We have to keep the human animal plastic and open to response and above all things, avoiding all kinds of specialization of fixing of type. We are middle-of-the-road animals and have won our victory by being able to beat every other animal at its own game and in its own element, and only by keeping that up will we succeed in improving the future of the race.

In the second place, we found that all our comparisons with the lower animals were vitiated by a serious fallacy, that while we could produce certain changes in the lower animals at will, by selection, those changes were not for their benefit; they did not improve them from their point of view or enable them to compete better in the struggle for existence, but were made for our benefit; and the proper selection of the human breed will not stand comparison for a moment with the

empt at so-called improvement and development of high grade stock in other types of animals.

The third thing we discovered was that the genius was a remarkably rare and fortunate accident and that the very fact of a genius having appeared in a family was pretty good evidence that there wouldn't be any more geniuses in that family for at least twenty or thirty generations; and finally we found that when the community had acted upon the principle of endowing the successful man with titles and official position, or landed estates in the hope that he would produce a class of people of greater value to the community, what really happened was that the brilliant and able man married a commonplace wife and produced commonplace children. So that we locked up, for the benefit of not more than 3 to 5 per cent. of the community, something like 30 or 40 per cent. of the resources of the right of primogeniture and by the unrestricted right of inheritance of private property, which is one of the things that will have to go down in the future. We had succeeded in starving and crushing out and killing at least five to ten geniuses in the great 70 per cent. of the people for every one we bred to order in the upper 5 per cent. of the community.

So the next line eugenics decided to take up was the negative side, preventing the reproduction of the obviously and clearly unfit. Here we had the advantage of having a criterion about which there could be no two opinions. It was perfectly possible to establish a criterion of normality and everyone falling below it was to be regarded as an unfit and undesirable type to reproduce, and it was not very long before we began to make the exceedingly interesting and most encouraging discovery that the larger part of those qualities which rendered the individual unfit for competition were things handed down to him from his ancestors and which would be handed down by him to his descendants. I need not detain you with the statement of the actual results of these investigations. They are familiar to practically all of you. But it was found that about from 2 per cent. to 3 per cent. of the community were congenitally defective and from that 2 per cent. to 3 per cent. sprang the enormous mass of our feeble-minded, of our epileptics, a large share of our insane, a large share of our prostitutes, a majority of our criminals and the vast mass of our paupers and tramps; that we had gathered together, as it were, in one stream and one line, a tremendous number of the undesirable and unfit element of society.

Plans were proposed at once for the limitation and the cutting short of the further perpetuation of this type of individual and this contamination of the race stream, this pollution of the blood of the community. The most careful investigations have shown that never, from a feeble-minded father and mother, has been born a normal child—no instance has been brought forward where that miracle has occurred, and according to the percentage of defects, obvious or concealed, which exists in the parents, so will be the percentage of defects in the offspring. These conditions emphatically breed true and if we can manage to break this stream in one way or another, we shall succeed in stopping an immense number of these defectives and misfits of our human species. The method suggested for doing this is the simple one of extending the care of the schools so that intelligent experts in mental development, intelligent physician, and a born teacher, shall examine every child in the community, certainly as early as three years and preferably earlier, and watch for the development of the little peculiarities, showing these hereditary defects. When these defects are discovered, those children should be taken and placed in a special environment out in the country under the most favorable and happiest circumstances and trained and developed to the highest pitch they can possibly be, but prevented from reproducing their kind by permanent segregation. When this has once been done, it would only be a few decades before we should see a rapid falling off in the percentage of pauperism,

crime, insanity, epilepsy and feeble-mindedness.

The question is now, are we producing this defectiveness, this feeble-mindedness, these hydra-headed forms of defectiveness? Is it a breakdown under the strain and stress of civilization, or is it merely the persistence from an almost indefinite period in the past, or radically defective strains?

In other words, are we manufacturing our defectives or are we merely perpetuating the defectiveness which has been inherited from past generations? On that subject a great deal of admirable work has been done, resulting in the conclusion that we are not manufacturing defectives, that the strains of civilization are not producing mental defects which manifest themselves in the form of feeble-mindedness, epilepsy, insanity and crime; that these are not increasing under civilization, but that we are simply perpetuating, from some far period in the history of the race, a strain of mental and physical defects. It is merely an arrest of development, the lowest type of the feeble-minded is the individual whose development is arrested at about the age of the child of two; the next lowest is one whose mental development is arrested at about the age of a child of six, and the next lowest is one whose development is arrested at about the age of a child of nine, and so on, until, if we go very much further, we might begin to make invidious personal comparisons which would not be altogether—well, you don't want to carry anything too far, as Doctor Sedgwick said.

The situation appears to be that there are two great reservoirs of this mental defectiveness, one of them being, not the city slum, for that has a lower percentage of feeble-mindedness, epilepsy and insanity than the poorer and remoter class of open districts which are the real rearing places for our defectives and feeble-minded—but the little colonies which dot our country all over from the fisher villages of Nova Scotia and the coves of the Allegheny Mountains, to the pine barrens of the Southern States and the swamping river-bottoms of the West. Probably everyone of you has known of some such community of chicken thieves and drunkards and paupers and feudists and smoke-house robbers who live off by themselves and interbreed, protected from elimination by the very low grade of their surroundings and the small amount of strain which is brought to bear upon them. They live like animals because they have an animal mentality and are placed under animal surroundings.

The other reservoir for that defective strain is the group of privileged doodle-wits at the other end of the social scale, whose eccentricities have been carefully preserved and protected from the fool-killer on royal thrones and in millionaires' families, in Four Hundreds and upper Ten Thousands and groups of that kind, safe from the competition and pressure which would otherwise have wiped them out of existence. In the intermediate and lower ranks of life there are not so many of these defectives, but there are historical instances that recall themselves, of a magnificent succession of degenerates. Indeed if sterilization of defectives had been insisted upon in the past at least three royal houses in Europe would have been put out of business generations ago. I do not mean to say that there is naturally any greater proportion of defectiveness among them than among other elements of society, but they are maintained by their family and rank and kept in a position where that defective strain can spread and trickle downward; it is even considered an honor by the remainder of the community to have it mixed with their blood.

The question to what extent two great sources of deterioration produce this defectiveness is, I think, worthy of a moment's attention. They are the two great curses of civilization, alcohol and syphilis. Is it true that we are filling our jails and asylums and homes for dependents, because of the use of alcohol and the prevalence of syphilis, or is the relation the reverse action? That is, that alcohol is a germ poison, picking out the weak individuals and detecting the weak spots in the community, instead of actually causing them? The general

weed, I think, of investigation, tends in favor of the latter view. We can hardly imagine it to be otherwise when we remember the way our ancestors used to boast of the number of bottles of port they could carry. We would all have been dead long ago if mere alcohol had been sufficient to produce defectiveness. I don't know whether any of you remember the standards that obtained when the first temperance society in New England less than a century ago was formed. Its pledge ran as follows: "We, the undersigned, believing in the evil effect of strong drink, do hereby pledge ourselves on our sacred honor that we will not get drunk more than four times a year, Muster Day, Fourth of July, Thanksgiving and Christmas." That was the beginning of the first temperance society, and a community which could stand such potations and saturations as that, is not going to be seriously damaged by the drinking that is going on at the present date. I believe that these two conditions, instead of producing defectiveness, merely pick it out and we should regard the drunkard and the individual who goes insane from syphilis as emphatically not to be trusted to reproduce the race. That our laws as regards divorcing such individuals should be made practically self-acting instead of encouraging good women to marry men of this description in the hope of reforming them by their Christian principles and their good example; that, I think, is distinctly immoral, I care not who has upheld such a position.

The last bearing of this question that I should like to call to your attention is as to the amount of this type of defectiveness. Of course we can pile up perfectly enormous and appalling figures running up into the hundreds of thousands, of the different types of defectives—feeblemindedness, criminality, insanity, prostitution, etc., but, taken altogether, they do not come to more than 4 per cent. or 5 per cent. of the total community; 95 per cent. of the community are born normal and sound and the vast majority of us, no matter what strains we should be subjected to, are hopelessly and monotonously sane, not even cranky enough to be interesting. The general average of the race is high and good, and the real field of eugenics, in my judgment, is the recognition of this fact, first of all. By all means, weed out, by appropriate and kindly segregation, those unfortunates who have been born accursed and prevent them from passing on that tainted plasm to the next generation, and we should soon see a marked improvement in affairs. The next thing is to alter our attitude to the great mass of the people—and that has been the most serious and dangerous result of this strain of defective plasm in the race. We have actually taken, in our inspired intelligence, that 2 per cent. or 3 per cent. of defectives as the creatures which all men would become if they were not held down by the strong hand of the law or upheld by the support of religion. We have pictured 2 per cent. or 3 per cent. of defectives as the basal type of the entire community and have allowed that to color our laws, our prison regulations and our methods of what we are pleased to term justice, until we have produced a code which, for savagery, stupidity and ineffectiveness to 97 per cent. of the community is never needed for a moment, except by the 3 per cent. of unfortunates at the lower end of the scale. We should recognize that the tendency of 95 per cent. of humanity is upward and forward and that the vast majority of men would be law-abiding if there were no laws. That the place where our geniuses and our great men and desirable individuals are bred and born is in that 75 per cent. to 85 per cent. of the race, which is the backbone and seed bed of every people, and that the main thing needed in eugenics is to preserve and conserve the virtues of the heredity of 90 per cent. of us. I believe that we shall come to feel more and more that the man who is to be chiefly regarded is the average man and not the exceptional man, neither the exceptionally and unnecessarily good nor the exceptionally bad. That the people to whom we should direct our attention and for whose welfare we should work, are, in Lincoln's phrase, "the great, plain people whom God Almighty must have loved, because he made so many of them."

REVIVING A DYING INDUSTRY

WHAT A TECHNOLOGY GRADUATE IS DOING IN SCIENTIFIC AND SYSTEMATIC CULTIVATION OF CLAMS. RECLAIMING FLATS EXHAUSTED BY OLDER PRACTICES

BY JOHN RITCHIE, JR.

Revival of neglected and wasted sea-farming opportunities is a matter that is much discussed today in Massachusetts and is attracting some capital. The whole subject is timely on account of its direct relationships to conservation and is of especial interest to Science Conspectus and its readers in that the initial scientifically directed effort lies to the credit of a past student of the Institute of Technology. The systematic first work towards reclaiming the neglected sand-clam flats has been deliberately undertaken by Andrew Kerr, '06, a student in the courses in biology. Sea farming has been much developed by the older nations especially in the Orient, although the efforts here have been devoted to utilizing sources of food not yet available to the Occident, being driven to it by necessity as these people have been to their intensive cultivation of the land.

There are some of the shell-fish that have always been taken for food and a few of these have been developed for the reason that there is known to be large profit in the systematic cultivation of them. The oyster has been a staple for decades and the minutiæ of its care have been reduced to a science. Likewise the value of the industry has led to laws which have made it practicable to develop it. Another shore crop has come more recently into vogue, the little neck clam, which is grown—though without much science—for the great returns that it will yield. The third of the shell-fish group in Massachusetts waters is the scallop, much esteemed, but subject to the traditional belief, fortunately lately dispelled that they may be here today and tomorrow pull up stakes and go to some unknown locality. These three fisheries are more or less in the public eye, but no one hears much about cultivating the sand clam, Mya arenaria, the favorite for bakes and chowders, although if properly carried on the industry may be quite as profitable as either of the others.

So far as the oyster is concerned, since the annual consumption in this country is about fifty cents per head of population, the importance of the industry has led to laws which, like the laws pertaining to agriculture, protect the oyster grower in harvesting his crop. The quahaug is not protected, but the places of its growth are similar to those in which the oyster develops so that cultivation on oyster beds affords a measure of protection. The scallop is to a very limited degree migratory but not regularly or in schools or to a distance. The laws have had reference largely to "seed" scallops, quantity to take and close season, with some local town regulations. And as for the sand clam, it is practically without protection today, although there are plenty of places suited to its cultivation. The general attitude of the laws, the reckless wastefulness of the clam diggers and the sinfulness of the community in polluting good beds with sewage are rapidly driving the clam out of existence as a Massachusetts food supply for Massachusetts people.

This situation is not a new one. For a decade and more the Fish and Game Commission of this State has been calling attention to the necessity for a different policy. Notice has been given to prominent cities that are befouling neighboring flats that might yield their fishermen good profit, and an educational campaign in literature and addresses has not been wanting, but it has remained for Mr.

Kerr and his associates to make the definite proof of the pudding, to undertake in a commercial way the scientific and systematic culture of the clam and the reports from the clam farm at Plymouth are highly encouraging.

To outline the legal situation in Massachusetts with reference to the clam and other edge-of-the-water shell-fish, it is merely necessary to say that in the patriarchal spirit of its early days the Colonial Government of the province gave to every one of its citizens the right to take a daily ration of clams from the shore wherever they might be found. The principle is a familiar one in everyday practice for any one may fish from the rocks that jut into tide water, or hunt along the tidal shore and shoot at birds unless there are definite special restrictions.

The law makers have realized that indiscriminate hunting is killing all the birds and to some extent they are now protected, but the limitations to the taking of shore products are little greater than in Colonial days. The injustice of this freedom makes itself felt more and more as the population increases. One may plant potatoes in his field and be assured that he has some legal right to his crop, for custom and the laws support him here, but one's crop of clams on the beach is at the mercy of the first citizen who thinks he would like a clam supper. Even the experimental grounds occupied by the State at Essex were not free from invasion. Here, since the sower has no certainty of reaping, there has been no care about replenishing the stock, no cultivation; but on the contrary, continual waste. No one is careful of what does not belong to him, and citizens in general are particularly wasteful of what belongs to the municipality or state, so the diggers of the past have had no thought for the morrow, but in taking for their immediate needs have exposed growing and seed clams to conditions that have tended to destroy them. The clam candle has been recklessly burned at both ends, the older clams have been eaten and the young ones left to die. Little wonder is it, then, that Duxbury and Plymouth, famous in older days are now practically out of the ranks of the producers, that Essex and Newburyport have lost most of their crop, that in Fall River and Buzzards Bay the flats have become exhausted, in these latter places notably by the destruction of the seed clams, while the great Boston harbor has been proscribed on account of pollution by sewage. Other places are in the same predicament. Portions of New Bedford Harbor are condemned, and suspicion seems now headed towards certain important clam flats of Newburyport. One can hardly credit that an important industry in a desirable food product can have been so neglected and is almost at the point of passing into the hands of out-of-the-state communities. The more unfortunate would this finality be when it is remembered that there are at least ten thousand acres—nearly sixteen square miles—of clam flats that might be productive lying along the shore line of Massachusetts.

There is, however, a little relief, which shifts the responsibility for present conditions although it has not as yet changed them. There is an option that the town may ask of the Legislature, the administration itself of the shore rights within its borders. Three groups of towns, numbering in all five places, have asked for and received such authority, Plymouth, Kingston and Duxbury, abutting on the shore of the same harbor, Essex and Barnstable. Plymouth was the first to apply, the act dating back to 1870, and Essex and Barnstable are recent additions to the group. In Plymouth it was purely a movement of conservation. There were important fishing interests demanding bait and the clams were being exhausted. It was proposed, therefore, to begin the cultivation of the clams, to re-seed the flats and to assure to the fishermen a perpetual supply of bait. The fishing industry, however, established itself elsewhere and the policy of assigning flats to individuals was not taken up till the matter was brought to the attention of the authorities by Mr. Kerr, who now holds under this law.

The advantages of a shore industry,

Plate I. An undesirable flat. Seed clams catch here but will not grow. The seed clams were taken out of the space beneath them.

Plate II. Clam flat at low tide showing furrows.

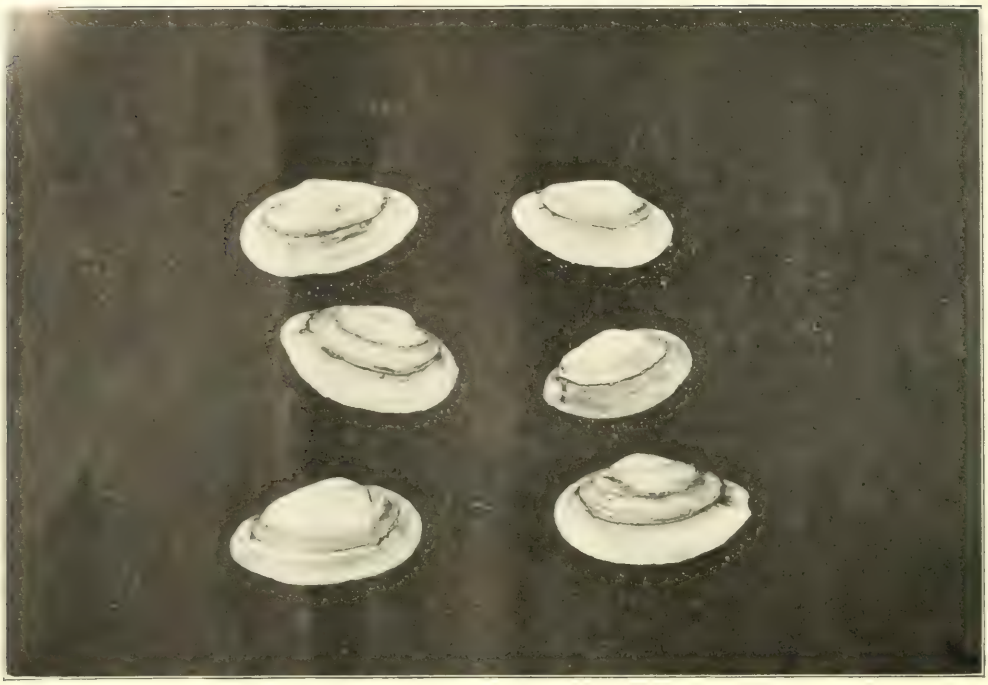


Plate III. Three months' growth, the seed clams being within the dark ring.

Plate IV. Eight months' growth. All outside the dark lines has been added during that period.

like the cultivation of clams, are not to be overlooked. Nature is working in the environment that she has herself established. The plants and animals live under conditions where the balance has been arrived at between creatures and their enemies. There is here no risk of drouth or flood, the serious ones on land, but there are the dangers of storms and destructive animals. Oyster beds are occasionally destroyed by storm-washed material, and the same is true of exposed flats, but in the former case the injury is infrequent, while clam flats, in positions where such damage is probable, have been destroyed long ago. As to destructive animals, the great spherical Natica that is the chief enemy of clams, is itself valuable for bait, and is taken for this and thus kept under control.

The fisherman who has a water farm may look for his crop year after year with regularity. It is not an itinerant shoal of fishes, here today and tomorrow off on a globe-finning expedition, as the tile fishes are wont to do. There is in the shell-fish farm a crop more certain than any thing on land, save the weeds, and these are helped, just as the mollusks are, by environment. The man who raises wheat or corn may realize, it is said, from twenty-five to thirty dollars an acre in New England, or he may cut a ton of hay. Alfalfa, the farmers' easy way to wealth, may yield one hundred dollars an acre, and cranberries, when all the conditions are favorable, may touch two hundred and fifty dollars, and this is about the yield that the clam farm will assure. There are intensive cultivations like truck gardening that will go much higher, and there are, likewise, sea crops like the oyster and quahaug that may match them, but it is the staples that should be compared, when cultivated and harvested in easy ways by ordinary unskilled hands.

This setting forth of these premises leads to the main point of the argument, that here is an industry that is now taken out of the domain of guesswork or rule of thumb and placed on sound reality, for Mr. Kerr has secured his sea farms, sowed his seed and gathered his harvest. It was a deliberate line of action that he took to the present success. He realized the clam situation a dozen years ago through a boyish experience in Maine; the study of biology at Technology helped strengthen his plan and quietly he has been developing his work. It includes taking advantage of natural facilities when Nature is pointed the right way and the correction of errors when mistakes are made from the human point of view.

The conditions in Plymouth harbor present a large area of flats available for clam culture, which have practically been exhausted, and large reaches of gravelly bottom. The White Flat lies over towards Captain's Hill in Duxbury, about half a square mile in extent, and there is near by Ichabod's Flat of 270 acres. These are in the Kerr Sea Farm.

The clam is at first a free swimmer and it is the ordinary occurrence for it to be swept in quantities into unfavorable places. Here the little bivalves develop for a while, but have not the conditions to maintain their growth. They are crowded in what space is available, and presently are arrested in growth or die.

Such an uninhabitable stretch is shown in Plate I, the mass of clams having been taken from the ground directly beneath them. This will serve to show how thickly Nature may seed them in unfavorable places, where they cannot mature.

This temporary storehouse of gravel has been the source from which clams have been taken to stock the White and Ichabod Flats. It is a good reservoir and has yielded up to three or four thousand seed clams to the cubic foot, practically every one of them doomed to death if not removed from congestion and unsuitable environment.

The sea farms, as one may see from Plates II and V, are not so different from those on land. Furrows are dug and the seed clams regularly planted. They establish themselves in their new homes at once and testify to their proverbial happiness and satisfaction by taking on a rapid growth. Plates III and IV testify to this without the need of explanation, save that the shell included within the dark line marks the size of the clam when transplanted; the rest is growth on the

Plate V. How the clams are sowed in the furrows.

flat. The clams in Plate III were three months in their new home on White Flat and those in Plate IV show the comparatively enormous growth under good conditions in eight months. The latter are marketable clams.

There are carefully kept figures that tell the story of the growth, and an increase of twenty-fold in the weight of the meat after six months of cultivation is the average. Clams that have lived in the sand of the flat for two summers have gained about seventy-five times in the weight of the meat. When, however, they get to be very large, say from four to five inches in length, the growth is slow. Further than this there is a marked difference in the shell of the clam that develops in rocky reaches. The illustrations hint at this, but give little definite idea of the nature of the difference. Naturalists will know at once that the shell that is in rocky sea-bottom must itself be heavy in structure to withstand the vicissitudes of the gravelly surroundings, especially if there is motion to the water. The difference is really considerable, the sand clam from the flats having one-fifth of its weight in the shell and the gravel clam having one-third, so that two gravel clams may be considered as putting as much food and energy into the building of their shells as three of the clams from White Flat. With a million clams to the acre the ratio of shell to meat becomes of economic importance, and six hundred thousand to a million is the capacity of such a sea farm as White Flat, while in shipment, it is desirable to pay express on as little waste as possible.

The mysterious isothermal layer of the air, in which temperature ceases to fall with rise in altitude, has been chiefly investigated in Europe, but within the last year many balloon soundings have been made in Canada. These have shown the layer at an average height of 8.1 miles. Two Germans, Drs. Rampp and Wagner, have now begun a year's scientific researches in Spitzbergen, and are studying this strange air phenomenon in the cold of the polar night.

THE PYRAMIDS AS AN ASTRONOMICAL MONUMENT

PRIMARILY BUILT TO CAST A KING'S HOROSCOPE THE PYRAMID OF GIZEH WAS, APPARENTLY, A GREAT OBSERVATORY, THE GRANDEST EVER ERECTED BY MAN.

BY PERCIVAL LOWELL

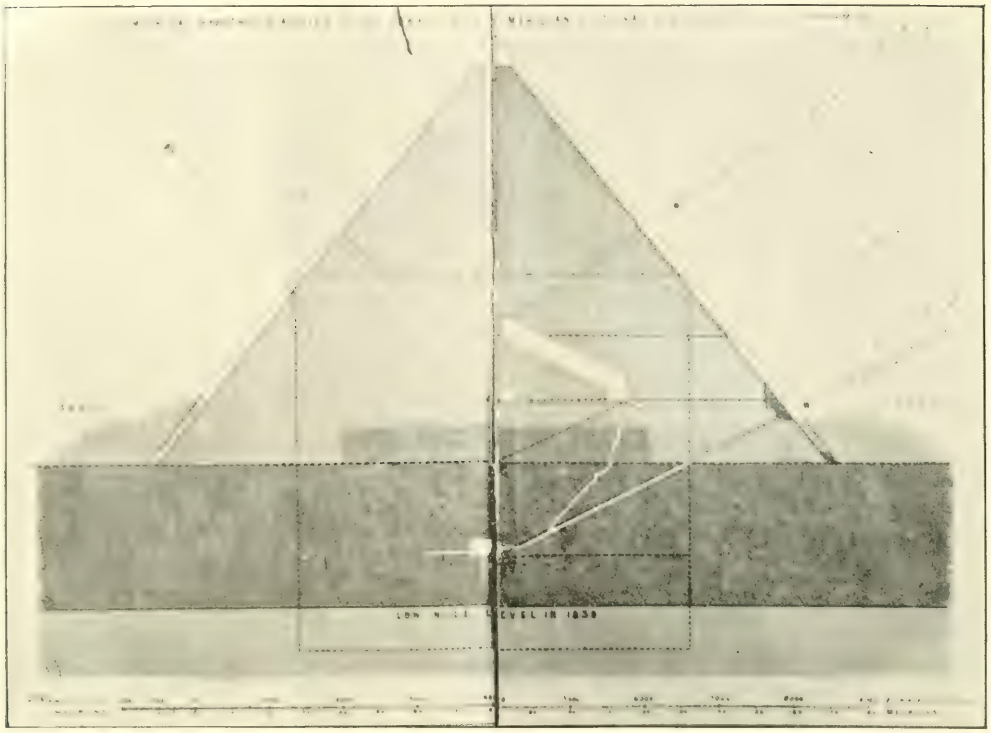
The Great Pyramid of Gizeh holds in itself, perhaps, the most romantic and certainly the most majestic period of the past. The story which it conjures up, as you will shortly see, will, I trust, bring vividly before you a scene, the grandeur of which—although it is science pure and simple—is unsurpassed.

Most people date their acquaintance with the Great Pyramid from their first school geography in which a solitary camel and unlimited sand typify the desert. Rising from this picture to a perspective view in ancient history they next acquire of it, to judge from the text-books, much miscellaneous misinformation. Thus one of the most popular of these purveyors to the young in secondary schools informs the innocent that: "*The* Egyptian art was architecture, especially of the temple and the tomb" and that "of the last the Pyramids are the great example" though "only exaggerated reproductions in stone of savage grave mounds like those of our early North American Indians." This startling nugget of knowledge is true only in the *grammatico-algebraic* sense that two negatives make an affirmative. For they are not examples of art on the one hand, nor are they Egyptian on the other. They are, in fact, the embodiment of Chaldean science. Now science is the acquisition of truth; art the perpetuation of beauty. The two are as distinct as are generally the good and the good looking.

Youth is next informed that the Nile has been credited with influencing their form the better to withstand its annual inundation. Considering that the oldest of them, the pyramids of Gizeh dating from the fourth dynasty, are carefully placed on the plateau well above any possible flood, this illuminating surmise may perhaps not hold water. But that serves to introduce us to the first thing we notice about the Pyramids: the shelf on which they stand and the latitude at which this shelf lies.

To be told that five thousand years ago the Southern Cross could have been seen by one standing where London stands today would certainly cause most people surprise. Nevertheless such was the fact. That celestial asterism to which persons who have not seen it look forward as to one of the revelations incident to voyages into the tropics and then, on beholding it, feel egregiously duped, needed then no far travel to disclose. The sad disillusioning caused by its rising could have been enjoyed without leaving home. For 3000 B.C. its center-void apology for the real thing might have been observed above the outline of the South Downs at midnight at the proper season of the year by a stargazer at the then mute and inglorious Greenwich.

If amazed at the apparition our tourist thus transported back in time turned to get his bearings from the north, not less astonished would he be to discover his old friend, the pole star, unaccountably gone. Even the learned might experience a shock. Certainly to those who drink in their star knowledge through the medium of the Dipper would it prove disconcerting to find Polaris adrift in the sky. Its fixity fled, our cynosure would indeed be difficult to detect. Just as mediocrity exalted by office sinks into plucked insignificance once its insignia



Geometrical Hypothesis applied to Colonel Howard Vyse's Meridian Sectional Elevation of the Great Pyramid

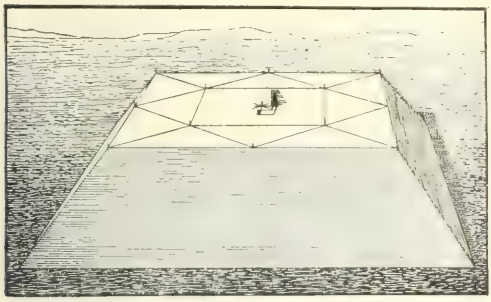
are removed. Nor would he find the solace of familiarity anywhere else. For such upsettings of fundamental fact would confront him everywhere. The whole firmament would appear to be turned topsy turvy could we suddenly be canopied by the heavens of those departed days. All the constellations would seem askew even if he succeeded in making them out. Nothing new under the sun! perhaps; but a very different state of things under the midnight stars.

Not only was α Draconis once the pole star, but it was actually so seen of men who have left us record of the fact. And this, too, without the slightest idea that they were dating history, and in the most dramatic manner possible. Not by carved or written inscription, not by oral tradition handed down by word of mouth, was this accomplished, but in a way at once more silent yet more sure—mutely embodied in the very core and being of a building the grandest ever erected by man. The Great Pyramid, the pyramid of Cheops, tells us this in stones that bear no character at all and only astronomy can read.

Herodotus, the "Father of History"—known also as the father of lies in what may be called the Ananias Club sense, for we are now learning that what he narrated, though seemingly unbelievable, usually turns out to be true—informs us that when he was in Egypt he was told by the priests that a long time before certain peoples had come down from the north, possessed themselves of the Egyptian power and so far affected the mind of the then King Cheops or Suphis that he forsook the Egyptian religion, caused all the temples to be closed and set to work under the stranger's direction to build a huge pyramid of stone.

The same veracious if also voracious historian goes on to say "that 100,000 men were employed for twenty years in building it; that Cheops was succeeded

by his brother, Chephren, who followed his pyramidal example; and that by the space of one hundred and six years all the temples of the kingdom were closed." In consequence the pious Egyptians deprived of their natural religious vents "detested the memory of these kings"; as they may well have done for other than religious motives, seeing that they were employed at forced labor on such a scale for such a length of time.



The Great Pyramid Observatory

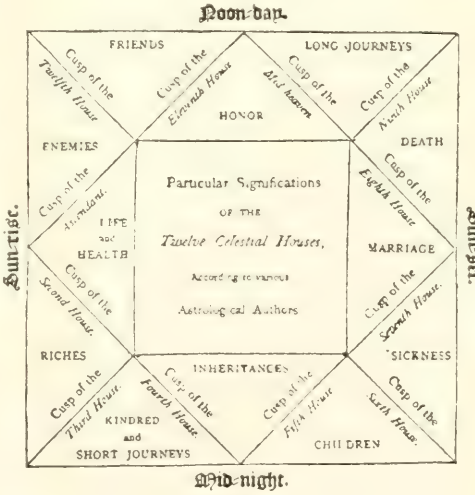
Manetho, who confirms the royal apostasy mentioned by Herodotus, gives us to suppose that we have here an invasion of the shepherd kings about the time of Abraham. Their force seems to have been intellectual, as they overturned the whole Egyptian system of things, he says, without a battle. So that they were probably Chaldeans, and the pyramids which they caused the king and his successors to construct were not Egyptian monuments at all, but embodiments of a foreign cult peculiarly distasteful to the followers of Isis and Osiris. Indeed, as we shall presently see, they were neither Egyptian nor monuments.

What they were not is plain; what they were has best been deciphered by Proctor, who has shown well nigh conclusively that their purpose was astrologic. That they were astronomic constructions they themselves reveal, and the only rational explanation of the power the strangers gained over the mind of the king lies in the astrologic art the Chaldeans are known to have possessed, and which is also known to have been eagerly sought after by all the peoples of the east.

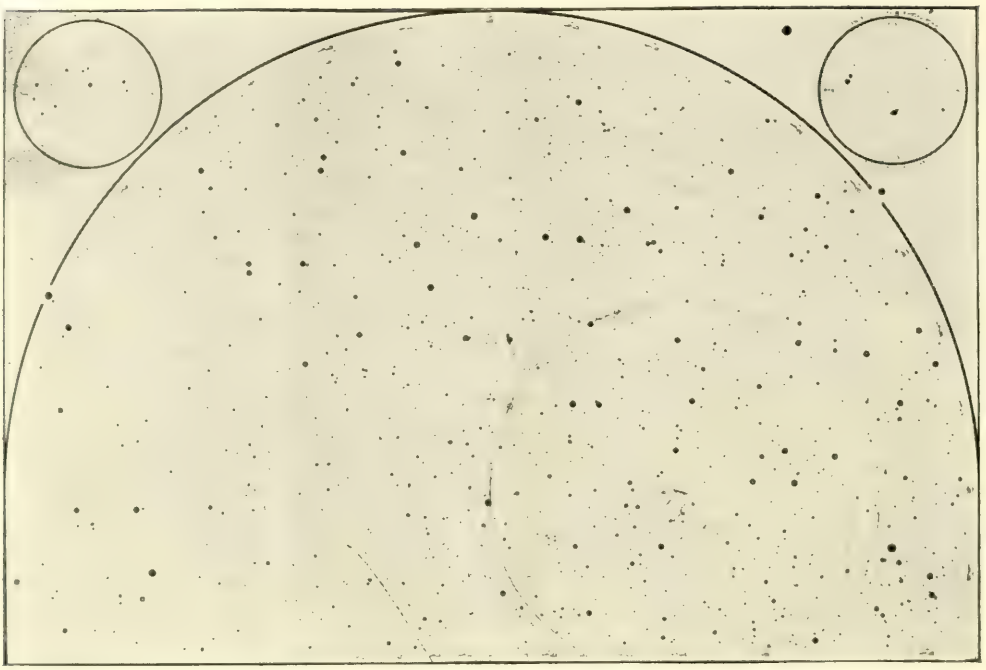
Both without and within they testify to a very heavenly regard on the part of their builders. In the first place their situation is expressive. They stand within a mile of the thirtieth parallel of latitude and undoubtedly were only prevented from standing nearer that astronomic line by the fact that the plateau shelf on which they were erected here falls abruptly to the plain. At this point on the earth the north pole is 30° high, and thirty degrees has this commendation to geometers, which the pyramid builders emphatically were, that a perpendicular from it to the line of sight is at that elevation exactly half as long as the line of sight itself.

In the next place the base of the building is four-square, its sides being oriented to the compass points with surprising accuracy. Just as Christian churches face the east, that is Jerusalem, and Mohammedan ones Mecca, so the pyramids faced the north. Here then we have surmise of both religion and astronomy, to wit astrology, embodied in the mere outward aspect of these constructions.

This is, however, as nothing to what the interior reveals. Upon the north face



of the Great Pyramid a passage opens, descending for 350 feet through tiers of stone at first, then through the solid rock. This passage points to the north within 4′ or 5′ in azimuth, is perfectly

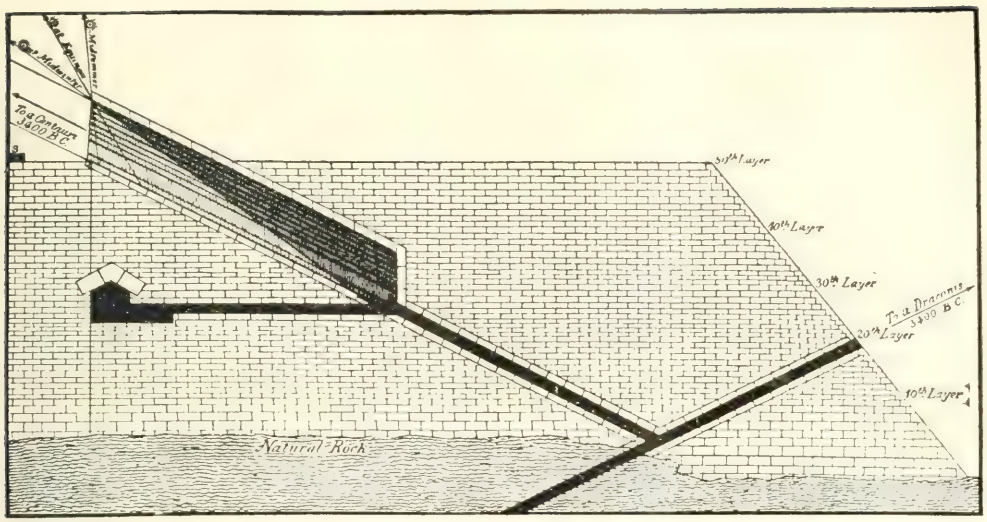


The Great Precessional Path, and the wanderings of the Ecliptic Pole

straight and is inclined to the horizontal at an angle of 26° 27′. The long straight hole suggests that it was used for looking at a star, for down it a bright star might even be seen by day. Its direction, moreover, hints that the pole star was the one in question. Now the latitude of the pyramid is 29° 58′ 51″. The subterranean tube, therefore, does not look directly at the pole; but when we take refraction into account we find that it would look exactly at a star distant 3° 34′ from the pole when that star was at its lower culmination, that is, passing the meridian directly south of the pole.

Now if in latitude 30°, a man wished to observe the north or south passage of a circumpolar star, in order, for example, to ascertain true north, the best means of doing so would be to dig a subterranean passage-way pointing approximately northward and then mark through it when the star ceased to rise or sink; and since either culmination would suit him he would naturally choose that one in which the slant of his tunnel would be the least, both because he could dig it easier and because he could descend it best. An incline of twenty-six degrees is distinctly preferable to one of thirty-four. Now 645 years before or after the date when α Draconis was approximately upon the pole, it was 3° 34′ distant from it; that is, in B. C. 3430 or B. C. 2140. The passage, then, chronicles the time when the pyramid was built—with a seeming choice of alternatives. But the nearer of these is negatived by what we know of Egyptian history and we are thus left with the other, that of B. C. 3430, as the date of the pyramid's construction. The pyramid thus dates itself astronomically, which is the first remarkable thing about it.

It is to be noticed that astronomy here furnishes Egyptology with a fixed epoch from which to go forward or back. We are not here dealing with conjectures as to when a certain king or dynasty can be made to fit into a general chronologic



Vertical Section of the Great Pyramid showing the Ascending and Descending Passages, Grand Gallery and Queen's Chamber

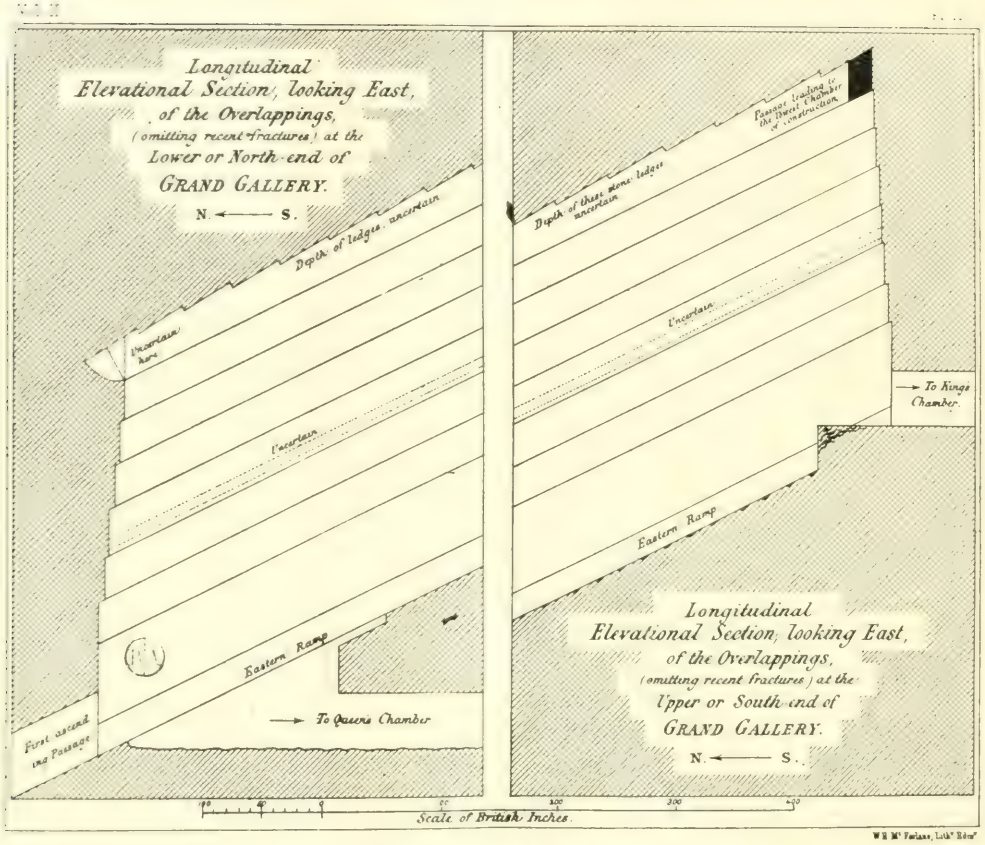
scheme by the relics it has left us of itself. Calculations from known astronomic data can tell to an exactness gauged only by the size of the opening of the passage as seen from below precisely when the pyramid was built with only the choice above described. To deny which would but argue a lack of appreciation of physical science. For that such a pointing can be but the sport of chance, the whole structure of the pyramid emphatically denies.

The Great Pyramid was in fact a great observatory; the most superb one ever erected. The building is the most mammoth in the world, and it had for telescopes something whose size has not yet been exceeded. This something, which did those old astronomers for instrument was the Grand Gallery. As its name implies this was a stone gallery of imposing proportions set on an incline of 26° 17′ 37″ in the very heart of the structure and pointing south. It is approached by the descending passage which looked at the pole star and thence by an ascending one at about the same angle which opens into it. It is one hundred and fifty-seven feet long, twenty-eight feet high and about eight feet wide. Along the center of its floor a smooth stone flagging ascends, flanked on either side by raised curbs or ramps half as wide each as the central paved pit. These curbs are not continuous but are cut at approximately equal intervals of about five and a half feet by notches with vertical edges. There is no doubt that these were for the insertion of benches, as the notches tally on opposite sides. At about sixteen feet from the bottom the central incline stops in a vertical wall which descends to a horizontal pavement, giving entrance to the corridor which runs to the Queen's apartment.

The roof of the gallery is everywhere smaller than the floor, so that it overhangs the bottom about one foot eight inches on three sides, 39.5 inches at its southern top. The stones on the sides are carefully set in tiers, the sides themselves being oriented to the compass points. Its exact dimensions which we shall find telltale are:

	Inches
Inclined length of floor	1,815.6
Same produced to south walk	1,883.0
Height	339.0

It is now of course walled in by stone on every side, but in the day of its use it undoubtedly stood open at the top, the horizontal passage in which it now ends at the summit having been the beginning of the platform of the whole pyramid, at that height. No records tell us this; our



Longitudinal Sections of the Grand Gallery

information comes from the gallery itself. Now if we calculate the angle from the vertical which the end of the cornice makes with the upper end of the floor we shall find it 6° (6° 20′). Remember that the gallery faces due south, so far as the builders could place it, that the latitude was 30° (29° 58′ 51″) and that the obliquity of the ecliptic was then 24° (24° 4′). Now subtract the second angle from the first to get the altitude of the sun at the summer solstice, and we have 6°. Consequently at that season the shadow of the gallery roof would just strike the south end of the gallery floor. A curious astronomic coincidence, you say. But go a little further. Let us calculate the angle from this same coping down to the end of the central incline on the gallery floor. It comes out 36° 16′. Now at the winter solstice the sun was 30°+24° from the zenith or 54°, that is, 36° from the horizon, the angle just found. In midwinter then the sun shone just to the bottom of the effective gallery, as at midsummer it had marked its top. Between these two extremes the shadow must always fall. Thus the gallery's floor exactly included every possible position of the sun's shadow at noon from the year's beginning to its end. We thus reach this remarkable result that the gallery was a gigantic gnomon or sundial telling, not like ordinary sundials the hour of the day, but on a more impressive scale, the seasons of the year.

That the gallery itself extends below the point where the central incline drops vertically to permit of entrance to the Queen's Tomb with its ramps notched, as

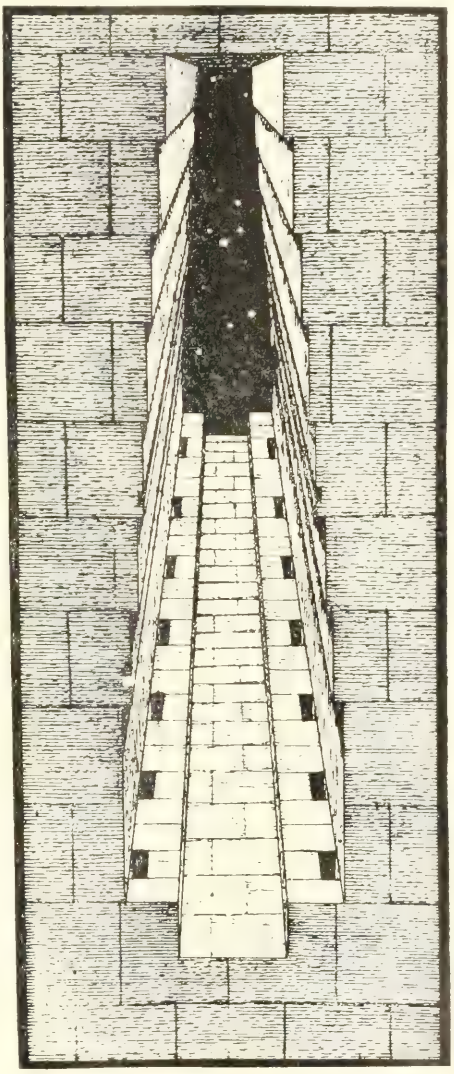
above, does not vitiate the deduction, for observers could not generally be placed on benches with their legs hanging down, however they might be so located on emergency. The recognition of this function of the gallery is not new, being, I believe, due to Proctor, but the exact coincidence of the limits of the effective gallery with those of the sun has, to my knowledge, never been pointed out.

Such, then, was the use of the entering passage, and such the design of the Great Gallery. Grand as was communion there with the sky by day, it must have been sublime at night—alone with the stars in the heart of that superb monument of stone. About the year B. C. 3430 it was further heightened by a spectacle which could not be witnessed now. Calculation shows that the great star *a* Centauri, the brightest and nearest to us of all the fixed stars, shone then at its upper culmination night after night down the hushed and polished vault of the Great Gallery.

a Centauri now hardly peeps above the pyramid's horizon at its highest, and in a few more years will never rise there at all until, thousands of years hence, the pole in its majestic precessional march raises it into view once more.

In a peculiar sense the pyramid was the man for whose use it was built. Primarily its purpose was to cast his horoscope through life, and then when his days were ended it became his tomb. He was buried in its interior. What had been its astrologic platform on top was continued on to an apex and then the whole structure sealed up, to remain, so it was fondly hoped, inviolate through time.

One reflection well worth our thought the pyramids suggest: the enduring character of the past beside the ephemeralness of our day. We build for the moment; they built monumentally. True we have printing which they had not. But libraries are not lasting. Fire accidental or purposive has destroyed the greater part of the learning of the far past and promises to do so with what we write now; and what escapes the fire, mold may claim. Only that idea which is materially most effectively clothed can withstand for long the gnawing disintegration of time. The astronomic thought of the pyramid builders lives on today; where will record of ours be, I wonder, five thousand years hence. We may be quoted



Vertical Section through the Grand Gallery.

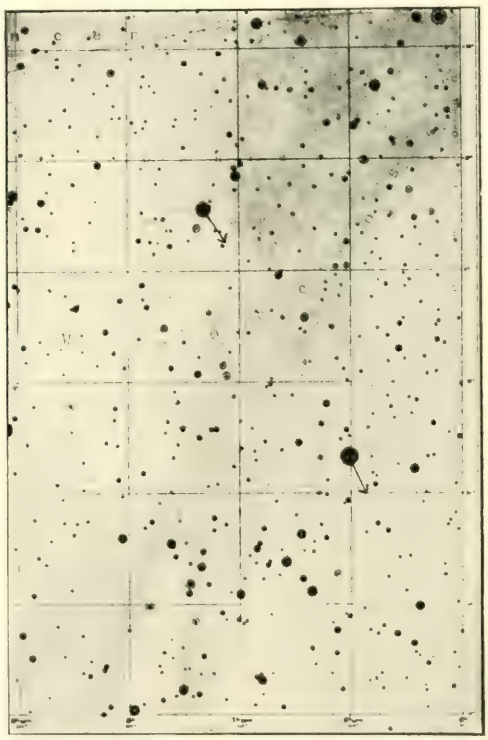
indeed with ever-increasing inaccuracy of transcription, but the star priests of *a* Draconis's time speak in their own words still.

To us Cheops is hardly more than a

name; long since his ashes were scattered to the winds; but the building those old Chaldean soothsayers constructed for him remains, not only today the grandest monument of man but the oldest and most significant astronomical observatory the world has ever had.

Now it has probably seemed to you that we have gone a long way back together—fifty-three hundred years—and we have found not savages, but scientists; we have found men, who, though practicing as astrologers for human good and ill, nevertheless were practiced astronomers as well, who knew immeasurably more about the subject than most persons today. To be confronted with such men of fifty-three hundred years ago may well cause us to open our eyes. I shall, however, carry you very much farther back still, for it occurred to me to add to this lecture tonight the oldest bit of history in the world, one that goes back so indefinitely far that it staggers imagination. It is a tale repeated by Al-Sufi. Al-Sufi was the great Persian astronomer of the tenth century. He wrote a "Description of the Fixed Stars" in Arabic a most valuable book which has come down to us and in it he gives an immemorial story about Sirius, Procyon and Canopus: Suhail (Canopus) had two sisters, Al'abûr (Sirius) and Al-gumaisâ (Procyon). Suhail married Al-djauza (Rigel) and seems to have had some domestic infelicity for he considered the best way out of his trouble was to kill her. By so doing he seems not to have angered any of her relatives—perhaps she had none—but his own two sisters Sirius and Procyon. Fearing their wrath, he fled toward the south pole, followed across the Milky Way by Sirius; while Procyon, remaining behind on the further side of the Galaxy wept till her eyes became weak. Hence it is that Sirius is called Al'abur, or the one that has crossed over. That is Al Sufi's story as given by the late Mr. J. Ellard Gore. Now, you will notice here first, that Sirius, Procyon, Rigel and Canopus are the biggest stars in this part of the sky. Secondly that from Babylon, they were all visible. For Babylonia lies in latitude 32° and we can see Canopus from latitude 35° nowadays very easily.

Now comes a surprising bit of modern astronomic discovery. Within the last two centuries Sirius has been found to have a large proper motion, that is an individual motion among the other stars, and this, as Mr. Gore pointed out, is of such amount and direction as to have carried it in the last 60,000 years from one side to the other of the Milky Way and in the



The proper motion of Sirius and Procyon in the last 10,000 years

direction of Canopus. Procyon, as he further remarks, having the same general proper motion as Sirius and being now on the north side of the Galaxy, has always been there. Two very remarkable coincidences these, to say the least, of the results of modern science with ancient tradition; a tradition embalmed in the name of Al'abur, "the one who has passed over." For, mark you, Al-Sufi knew nothing of the proper motion of Sirius; still less those who preceded him.

So that the tale could not have been invented to account for the fact.

This is not all. In consequence of the precession of the equinoxes Canopus swings around a curve the north and south axis of which is about 47°. It is at the present time as far north nearly as it ever can be and this was also the case 25,000 years ago, such being the length of the great precessional period. For the last 12,500 years it has been coming north, during the 12,500 years before that it was going south. It must have disappeared from view in Babylonia something like 22,500 years since—and did the same at previous intervals of 25,000 years. A tradition that it has sought the south pole is best interpreted as meaning that it vanished from the Babylonian sky southward. This it did 22,500 or 47,500 or 72,500 years ago. This then dates the tradition in another way and one which quite agrees with the action. Rigel has practically no proper motion so that here again the tradition is borne out. We reach then this amazing conclusion: that we have in this seemingly fantastic tale a tradition which is strictly in accord with several astronomic facts which were quite unsuspected till within a relatively short time.

Now I submit it to your own judgment: Could such a story possibly be made up with all its particulars, particulars so coincident with one another and with subsequent discovery. If not, then we have a bit of history dating from the stone age. And from such an age it is precisely the kind of lore we should expect to be transmitted. For watching of the stars is one of the oldest occupations of man, and any tales about them were sure to be handed down from one generation to another. Nor is anything so enduring. Think how the poems of Homer were preserved; all by word of mouth. For every mother tells such folklore to her child and the child remembers it as a man might not to tell again in turn. Extrinsically then the story would be likely as intrinsically it is true. Most probably then in it we have our oldest bit of history, an echo come down to us from the stone-age times.

THE EVOLUTION OF THE HORSE

Some idea of the immense lapse of time that has taken place to evolve the Eocene Hyracotherium into the modern horse is shown by Prof. H. F. Osborn as follows:

"The Rocky Mountains, it is true, began their elevation during the close of the Age of Reptiles; they had only attained a height of four or five thousand feet when the Age of Mammals commenced; they continue to rise during the entire period. But consider the map of Europe and Asia at the beginning of Eocene times and realize that the great mountain systems of the Pyrenees, the Alps, and the Himalayas were still unborn, level surfaces in fact, partly washed by the sea. . . . The birth of the Pyrenees was at the beginning of the Oligocene. At this time Switzerland was still a comparatively level plain, and not until the close of the Oligocene did the mighty system of the Swiss Alps begin to rise. Central Asia was even yet a plain and upland, and only during the Miocene did the Himalayas, the noblest existing mountain chain, begin to rise to their present fellowship with the sky. In North America, again, since the close of the Eocene the region of the present Grand Cañon of the Colorado has been elevated 11,000 feet and the river has carved its mighty cañon through the rock to its present maximum depth of 6,500 feet.

Those who have been impressed with a sense of the antiquity of these wonders of the world, and will imagine the vast changes in the history of continental geography and continental life which were involved, will be ready to concede that the Age of Mammals alone represents an almost inconceivable period of time."

The state engineer of Oregon has submitted a project for the largest water power installation in the world. It will develop 300,000 continuous electric horsepower at Big Eddy on the Columbia River. The hydro-electric units will be 32,000 horse-power each. It is estimated that the total cost will be about $23,000,000.

THE PHENOMENA OF CATALYSIS

REMARKABLE RESULTS PRODUCED IN CHEMICAL REACTIONS BY THE MERE PRESENCE OF CERTAIN SUBSTANCES WHICH UNDERGO NO PERMANENT CHANGE

BY W. R. WHITNEY

THIS is a purely chemical term and stands for the process of greatly increasing the velocity of chemical reactions by employment of materials which are not consumed in the process. Any analogy is apt to be misleading, but Ostwald suggests the parallelism between catalysis in chemistry and the effect in mechanics of the change from a too thick to a good lubricating oil on a shaft rotating under constant force. The speed will increase without application of additional energy. In a sense, this definition is too academic. In most of the processes called catalytic, the velocity-increase is so enormous that, without the catalyzing agent, the process would hardly take place at all. For this reason a catalyst is sometimes defined as any substance which *produces* a chemical action without being consumed in the process.

Catalysis is usually limited to describe cases where a definite material, or even a definite form of material, seems to bring about a reaction or produces a great increase in the velocity of the reaction. Heating the reagents produces great increase in velocity of most chemical reactions, and some are made to speed up by the effect of light, and so heat and light are sometimes called catalyzers. But it is customary to consider this type as at least partially understood and to class under catalysis the less easily explained cases, where the mere presence of some *material* apparently does the work and is yet not consumed. It acts more like the trigger of a gun. This sets off the reaction, which in our gunpowder analogy would otherwise be an exceedingly slow oxidation. The gunpowder might take a century to oxidize unless it were set off, although the products of the reaction would be the same regardless of the velocity.

It is very probable that for years catalysis was a word used, as such terms are often used, to classify or group together, without further commitment, a number of different phenomena which were not at the time explicable. It was known that hydrogen and oxygen could be mixed and would remain inert indefinitely, but that a little platinum or an electric spark in the presence of the mixture would cause rapid combination to form water. A finite quantity of platinum was able to produce the reaction between an unlimited quantity of these gases. Other finely divided metals acted similarly. The platinum was called the catalyzer. The spark in such a case was not usually considered as a catalyzer in the narrower sense. This is probably because the case is an application of intense heat which in any other manifestation is equally efficacious. It has been the custom to consider as cases of catalysis only those reactions in which the phenomenon can be ascribed to some material, thus excluding greatly increased reaction velocity due to light, high temperature, etc. It was known, on the other hand, that the decomposition of hydrogen-peroxide solution was greatly hastened or made almost instantaneous by colloidal platinum and other colloidal metals. Here again the metal was not consumed and had not lost any of its power after it had apparently accomplished so much. It was known that sugar in aqueous solution is ordinarily decomposed by the water into dextrose and lævulose with exceedingly low velocity, but the same reaction takes place very rapidly in presence of acids or certain organic ferments. Thus

the acid and the ferment were called the catalyzer.

It is known that many of our most common chemical reactions owe their velocity to the presence of water. In fact, water is the most common and most important catalyzer of all. It is much easier to find cases of chemical reactions which need water for any appreciable velocity, than it is to find reactions which can proceed in its absence. Yet in most of them the water apparently does not take part in the reaction nor is lost through it, and the same water could be used to an unlimited extent. Practically all of the common chemical reactions are of this type. Silver nitrate and sodium chloride do not react in the dry state, and the mere condition of solution is also not a criterion. While these two react readily when dissolved in water, they need not react appreciably when dissolved in some other solvent. This catalytic action of water, so common as to be usually lost sight of as a case of catalysis, is a very marked case because of its sensitiveness. The most refined methods have had to be employed to remove the water in cases where its effect was to be studied. For example, the ordinary explosion of carbon monoxide (CO) with oxygen does not take place if the gases are perfectly dried, but a trace of moisture makes it easy to start the reaction by a spark. Such active agents as gaseous hydrochloric acid and ammonia, which combine readily at ordinary temperatures, do not react in entire absence of water. And the decomposition or dissociation of ammonium chloride which in any ordinary experiment is readily brought about by moderate heating, will not occur in absence of traces of moisture.

The method of action may not be the same in these various cases, but the resulting great increase in velocity of action or even apparent production of the possibility of reaction and the non-consumption of the foreign matter or catalyst is common to them all. There are many other such reactions.

The various types of catalysis apparently differ widely, and while they possess in common the peculiarity which coördinated them under this head, they are being subdivided and grouped under new classifications because differentiating characteristics become gradually better understood. For example: there is a large group of chemical processes which are catalyzed by the presence of solids; sometimes by a specific solid, such as platinum, in other cases by a particular state or property of a solid, such as fine subdivision or large surface area, etc. A little palladium or osmium will ignite illuminating gas at the burner-tip in air. Some platinum, vanadium oxide, or even iron oxide will bring about the rapid union of sulphur dioxide and oxygen. These may be classed as surface effects, as absorption effects, etc., while it is not probable that reactions which owe their procedure to liquid or gaseous water can be so classed.

A number of catalyses may be looked upon as being due to the formation, for a short time, of products containing the catalyzer and one or both of the reacting substances, the catalyzer later stepping out of the reaction at its completion, much as the marrying parson leaves the wedding ceremony with his marrying power undiminished. In such cases it seems necessary to grant that the time necessary for the catalyst to unite with one of the reagents, and for the second to enter the reaction and the catalyst to back out, so to speak, is in all shorter than the time necessary for direct union of the reacting substances. This is possible. The catalyst often seems to be merely a means of in some way reducing the delays in a process. It can hardly be said to reduce the resistance to reaction, for reduction of resistance should cause a change in the total heat evolved by the reaction, and this does not occur.

Any treatment of this subject would be incomplete which did not mention the phenomenon of anti-catalysis or negative catalysis. As the name implies, this is the case where the presence of some otherwise inactive substance retards or prevents a reaction which would otherwise take place. In biological chemistry there are many such cases, and they are frequently referred to as poisonings. One

of the best known inorganic cases is that described by Bredig, who found that while the decomposition of hydrogen peroxide was catalyzed by colloidal platinum, iridium, etc., the presence of almost any one of the common soluble poisons was capable of destroying the action of the catalyst and of preventing the reaction. Hydrocyanic acid, hydrogen sulphide, arsenic, copper salts, etc., are such poisons. These poisons also act as anti-catalyzers to a number of biochemical reactions, ferment actions, etc. Water in most cases is an active catalyzer, but a few cases have been found where it is distinctly an anti-catalyst. Oxalic acid, dissolved in dry sulphuric acid, decomposes very rapidly, but the presence of traces of water greatly diminishes the velocity. The hydrogen ion is a generally active catalyzer. It shows its power in many cases of hydrolysis and in the action of enzymes, etc. The hydrolysis of cane sugar by acids depends upon it.

A multitude of reactions for which solid catalyzers have been found may be represented by one or two specific cases. Ammonia and alcohol vapors combine rapidly in the presence of heated thorium oxide, so also do phenols and alcohols. Titanium oxide and other metal oxides catalyze organic reactions without there appearing to be any predeterminable predilection. One is led to imagine that every possible chemical reaction has its specific catalyzers. Haber has said that every solid substance exerts some accelerating action on gaseous reactions, though some do it much more markedly than others.

It may be that all cases of catalysis are to be looked at as brought about either by the formation of intermediate chemical compounds of the catalyzer with one or both of the reagents and the subsequent breaking down of such compounds to the final reaction products, or of physical adsorptions corresponding to the increasing of concentration of one or more of the reacting substances.

The chemical industries are full of the most interesting and successful catalyses. Sulphuric acid manufacture has always made use of catalyzers in some form. In the early days it was the nitrogen oxides, and now it is platinum sponge, etc. When sulphur is burned in air, or oxygen, the dioxide is produced, and this, even in the presence of excess of oxygen, does not seem inclined to continue in the process of oxidation to the state of trioxide at any measurable rate. Yet this is the direction it should proceed, and any one of several triggers or catalyzers will effect it. It is very important to note that the final state of all of these catalyzed reactions is the "natural" state; that is, no consumption of energy is needed to reach the state, and energy is evolved by the process. The sulphur, in burning, *tends* to become the trioxide. Under normal conditions it only reaches the dioxide state in measureable time, but contact with such a solid as platinum sponge will catalyze the reaction, thus producing with great rapidity sulphur trioxide (the anhydride of sulphuric acid).

The great German dye firm, the Badische Analin u. Soda Fabrik, made careful study of catalyzers for the reaction between hydrogen and nitrogen by which they hoped to and finally did make ammonia commercially. The reaction was a perfectly possible one, but without catalysis it was always too slow to be practical. Finely divided iron, manganese, molybdenum, and tungsten were all found to be effective, and it was further found that these catalyzers could easily be poisoned by some reagents, but could be benefited by others. Thus arose the term "promoters" in catalyzers. A small quantity of some substance, such as an oxide, for example, serves as a promoter to the catalytic action of iron on the ammonia synthesis. Thus a practical and commercial process for direct synthesis of ammonia has been brought about. This reminds one somewhat of the complements and the immune bodies which, while coöperating in the blood, produce the effects of immunity.

There seems to me to be one simple way of looking at all catalyzers which is useful if it be not used unfairly. The velocity of reactions depends on the concentration of the reacting particles (molecules or ions, or whatever they may be). It is

not difficult to find in all cases of catalysis the probability of an increased concentration which is attributable to the catalyst. This is plain in such a case as platinum sponge and surface or solid catalyzers, for the absorption and adsorption of gases in such cases are well known. It is only a step along the path of this illustration to see possible intermediate physical and chemical compounds as concentrations of one or both of the reagents. Solid thoria catalyzes many organic reactions, so also does dissolved aluminum chloride. In the former case the physicist would grant the formation of adsorption compounds, and in the latter case the chemist recognizes the temporary formation of intermediate chemical addition products with the aluminum chloride. If we look at these two cases as cases of increased concentration of the reacting reagents, the possibility of coördination is clear.

The reactions in living matter (plant and animal) are very commonly catalyzed. Many of the catalysts have been named and have been isolated in more or less pure form. Malt diastase, which brings about the dissolving or hydrolyzing of starch, is such a catalyst. By its action in the germinating grain or seed, the reaction of the break-down, dissolution or solution of the starch is made rapid. The starch would be useless without this catalyst, and it is not used up by the reaction. This process is not confined to the cell or seed. It may be carried out in the laboratory. For example, a large mass of nearly solid starch paste may be made to rapidly liquefy by the introduction of a very small quantity of diastase. The enzymes ptyalin, invertin, emulsion, pancreatin, pepsin, and a score of others, are quite analogous. They each catalyze some reaction characteristic of some living process. Albumen and similar albumenoid matter is rendered soluble or assimilable by the catalytic action of pepsin, for example. The reaction is not a simple one between the pepsin and the albumen, but the latter causes the albumen to react with the water present and hydration occurs. A perfect explanation of this catalysis in life-reactions is probably not yet possible, but in looking for analogies of our apparently simpler cases, we are struck with the force of the fact that these digesting catalysts are known to absorb on, or absorb in the organic matter whose dissolution they catalyze. For example: if fibrin be suspended in gastric juice (which contains some of these organic catalyzers or enzymes), it can be shown that they leave the solution and are absorbed by the fibrin in which they are producing the decomposing reaction. They thus resemble the reacting gases which adsorb in the platinum of our simpler cases.

An exceedingly interesting recently investigated case of catalysis in the relatively simple reactions of the laboratory, corresponds so perfectly to a well known and apparently complex historical case in Nature that I make bold to present it.

It may be recalled that in that remarkable biochemical work of Pasteur's in connection with a study of the tartrates, he found that in the crystallized tartaric acids there were left and right crystals, shapes which corresponded as our left and right hands do and would not permit of even imaginary superposition. So also, when these were in separate solutions, one caused rotation of the plane of polarized light to the right, and the other to the left. When they are suitably mixed they form the optically inactive racemic acid. One of the ways, which he discovered for separation of these two forms when found thus mixed in Nature, was by means of the green mould pencillium glaucum. The growth of this mould caused decomposition or destruction or oxidation of one of these exceedingly similar chemical compounds (identical in quantitative chemical composition) more rapidly than the other; it showed such a selective catalysis as to distinguish between the two. This was a case of selective catalysis by the enzyme or ferment of the growing mould. Starting with the racemic, or optically inactive acid, he could stop the fermentation at a stage where only the lævo tartaric acid remained, the dextro tartaric acid having been destroyed.

Now quite recently, Bredig and his pu-

pils have studied the reaction of decomposition of bromcamphorcarbonic acid when catalyzed by small quantities of organic bases such as the alkaloids. They seem to have thus produced results very perfectly paralleling the above historic discoveries of Pasteur.

The molecular structure of the tartaric acids is such that, knowing this structure and knowing that an asymetric carbon atom will produce optical activity, it is now possible to predict such developments as the separation of some optically inactive material into two optically active ones. It was shown that in the decomposition of bromcamphorcarbonic acid, the organic alkalies act as catalyzers. This substance decomposes slowly into bromcamphor and carbonic acid. The process is catalyzed by organic alkaline bases, such as analin. The bromcamphorcarbonic acid has two optically active forms corresponding to the left and right tartaric acids of Pasteur. Both of them are catalyzed equally by optically inactive bases, but one of them is more rapidly catalyzed than the other by chinin as catalyzer, and the other is more rapidly catalyzed by chinidin than the one. Chinin and chinidin are themselves optically active substances, and thus it is found that an optically active catalyzer is capable of differentiating in catalysis between two optically active compounds and can catalyze the decomposition of one of them more than that of the other in a mixture of both, as Pasteur found with penicillium glaucum and the tartaric acids.

FROZEN MINE SHAFTS

In 1860 when the coal mining industry in Holland came to be seriously considered it was found that in the coal layers, except in two of the medieval mines near Kerkrade, there is a stratum of drift sand that contained quantities of water so great that it was not possible to build shafts that had any considerable depth. It was not until 1883 that Poetsch invented the "Freezing Method" which made it possible to reach these coal layers lying at a depth of three hundred to one thousand feet.

On the spot where the shaft is to be dug, from 25 to 30 borings are made down through the drift sand to the solid rock in a circle five feet larger in diameter than the projected shaft. Pipes are then sunk into these boreholes, and through these is circulated, by powerful freezing machines, a chemical solution cooled down to minus 20°. In this way the drift sand containing the water is frozen as hard as a rock after the freezing machines have been working day and night for two months. In this frozen cylinder of sand a shaft is then dug and lined from bottom to top with strong segments of cast iron securely soldered together.

The freezing method, thus applied, has successfully solved the problem, and Holland now has a flourishing mining industry.

TRANSPORTING LIVE FROZEN FISH

In extreme northern latitudes notably in Siberia, some of the great rivers are frozen solid to the bottom but the fishes thus imprisoned are not killed but resume active life when the ice melts in the spring. The *Fischerei-Zeitung* has been discussing experiments with the freezing of live fish for transportation, bringing up Pictet's experiments where fresh-water fish were put in a tub of water kept at the freezing point for twenty-four hours and then allowed to freeze slowly into a solid block of ice. This was afterwards cooled slowly to −4° Fahr. On melting the ice, even as long as two months afterward, the fishes swam about without showing any ill effects from the experience.

With reference to what can be done with the transportation of fish in this manner, cakes of ice with fish frozen in them have been wrapped in cloth and surrounded with heat-insulating material, in which condition they can easily be shipped. It is necessary to thaw the ice very slowly and to keep the water near the freezing point for several hours in order to preserve the life of the fishes.

SOME RELATIONS OF FLIES AND MOSQUITOES TO MAN

CONDITIONS UNDER WHICH THE GERMS OF INFECTION ARE SPREAD BY INSECTS—INSECT-BORNE DISEASES FOUND TO BE INCREASING

BY HARRISON G. DYAR

RECENT investigations have shown that certain insects have an important relation to disease. Not all diseases are related to insects, but the number found to be so is increasing. Diseases must be due to specific organisms in order to be conveyed by insects, and these divide readily into two classes. First, the bacterial diseases, or diseases caused by certain bacteria, such as typhoid fever, tuberculosis, anthrax, etc. The bacteria are simple organisms, without complex life-cycle, multiplying by simple division, their only modification being spore formation as a resting stage. The conveyance of these by insects is a purely mechanical one and essentially accidental. It is safe to say that the usual, normal mode of transference of such diseases is not through the agency of insects. We refer to such cases as the carriage of typhoid fever by the house fly. The usual mode of transference of this disease is by the contamination of water or food by the dejecta of former cases of the disease. In exceptional cases only is the house fly an important factor, where there is close proximity of exposed dejecta and exposed food.

The conditions are slightly different where the transferring insect pierces the skin, as for example with the stable fly. Here inoculation of pathogenic bacteria may occur, such as would be harmless by ordinary ingestion. In this class is the case of the transference of infantile paralysis by the stable fly recently investigated. The general condition is, however, the same. The nature of the transference is essentially accidental. It is quite true that these special cases may become of high importance and the transference frequent and dangerous, where the special conditions are repeated. Yet the nature of the transference remains accidental—it has no necessary relation to the life history of the parasite.

In the second class of cases the diseases are caused by protozoa, or forms of life still higher than these. The protozoa are organisms of some complexity, with definite life-cycles. All the organisms of this class are obligatory parasites, with alternate life-cycles, one passed in some insect, the other in some vertebrate. Without this alternation the parasite cannot continue to exist. The carriage of the disease by the insect is, therefore, not accidental, but a necessary step in the life history of the parasite. Each disease of this class has its own specific parasite, and the parasite is closely restricted in its hosts, generally but one species of insect and one vertebrate. For example, yellow fever, which passes one life-cycle in a certain mosquito, *Aëdes calopus* Meigen, and the other cycle in a certain vertebrate, man. The relation of the insect to the vertebrate must be a close one, or the alternating parasitism could not continue, nor could it ever have arisen. In the example cited, *Aëdes calopus* is a domestic mosquito, breeding in artificial receptacles of water and closely associated with habitations of man throughout the warmer climates. On account of the characters of this mosquito, being confined to warm climates below the frost line, the disease yellow fever is essentially a tropical one and only under exceptional circumstances can become prevalent in northern countries.

There is reason to suppose, although the matter has not been as fully worked

out as could be wished, that malaria is nearly as restricted in its hosts as is yellow fever. We find three types of malaria. Of these it appears that the common tertian malaria and the rarer quartern are conveyed by the mosquito *Anopheles quadrimaculatus* Say only, the pernicious malaria, by *Anopheles crucians*, Meigen, while *Anopheles punctipennis* Say, our commonest species, does not carry malaria at all. It therefore becomes important to distinguish between these mosquitoes and to collect full information as to their habits. The three species of *Anopheles* are very much alike and have similar breeding habits, yet there are differences. *A. quadrimaculatus* and *A. punctipennis* are well distributed throughout the eastern United States, extending their range to Canada. The tertian malaria is known practically throughout the range of *A. quadrimaculatus*, but the quartern does not accompany it so far to the north, perhaps on account of its comparative rarity. The same is true of *A. crucians* and the pernicious malaria, the host extending its range further north than the parasite seems capable of existing. It follows that in the northern states there is only one species of *Anopheles* carrying malaria, namely *A. quadrimaculatus*.

The breeding places of the larvæ differ in character in a general way. *A. crucians* prefers pools near the sea, slightly saline; *A. punctipennis* breeds in rain puddles and collections of water in various receptacles, cold springs, and to a less extent only in ponds, warm marshes or rivers; *A. quadrimaculatus* prefers warm permanent marshes containing algæ, sluggish streams or edges of lakes. I have never bred *A. quadrimaculatus* from the small temporary collections of water often found full of *Anopheles* larvæ and hastily pronounced dangerous to health.

It will be seen that exact studies of the particular insect concerned in the transference of each disease are essential in order that efforts to combat that disease may be effective. General measures against groups of insects will generally result in wasted effort, and especially if the climate remains unconsidered. For example, in Boston, measures directed against the breeding places of mosquitoes in chance receptacles of water, cisterns, barrels, puddles in waste land, etc., though laboriously and fully carried out, will not result in the reduction of any disease, for the *Culex pipiens* that breeds commonly in such places, is not a carrier of any disease affecting man, while the *Anopheles punctipennis* breeding in the same places does not carry the tertian malaria, the only form of malaria prevalent there. On the other hand, in Havana, the same measures transform a pestilential city into a sanitary one, for *Aëdes calopus* breeds only in such places, and its elimination or sufficient reduction means the elimination of yellow fever; *Anopheles albimanus* also breeds there, and it is the principal, or perhaps only carrier of the forms of malaria common in our tropics. Again *Culex quinquefasciatus* inhabits such places, and only such. Its sufficient diminution means the elimination of filariasis and its following disfiguring elephantiasis. A tropical city without yellow fever, without malaria, without filariasis and in addition without mosquitoes to annoy by night or day, has been robbed of its worst terrors, and can be obtained by the prohibition of standing water, unprotected by screens, within the city limits.

While flies and mosquitoes are not the only insects conveying disease, they are responsible for the majority of cases. Aside from their rôle in this matter, they become important to man on account of their annoyance. No one cares to dine in the midst of a swarm of flies, crawling upon his person and over the viands, while the plague of mosquitoes in many of our cities in summer renders sleep difficult or impossible. One cannot visit a public park, or even his own lawn in the evening without perpetual activity to drive away these insects. Many otherwise attractive summer resorts are neglected or deserted from the presence of woods mosquitoes or salt marsh mosquitoes. The conditions in the cities could be so easily mitigated by a little well directed activity on the part of the

city authorities that it seems a shame that the citizens should be subjected to them. These mosquitoes belong to only two species, *Culex pipiens* L. and *C. quinquefasciatus* Say, neither of which breeds at large in natural collections of water, but only in the receptacles supplied by men. In cities such as we have in mind where there is municipal water supply and sewers, they breed in the cesspools small and large, but principally in the basins at the street corners used for retaining the heavier street dirt from entering the sewers. The occasional breeding in neglected tins or other articles is too small to affect the supply and can be disregarded. The protection of sewer traps by screens, the occasional oiling or periodic flushing would prevent the breeding of these mosquitoes, yet year after year the plague continues, thousands of citizens flee to the dubious delights of summer resorts, while those forced to remain have life made miserable by nightly torments and their vitality reduced from loss of sleep, or else suffocate under nets.

In summer resorts outside of cities the conditions are different. Other species of mosquitoes are involved, with other habits. In resorts upon the sea shore affected by mosquitoes, the salt marsh forms are concerned, *Aëdes sollicitans*, *A. cantator* and *A. tæniorhynchus*. These breed in the temporary salt water pools near the sea, and the adults fly long distances, often troubling communities many miles from the breeding places. The only remedy for these species is the reclamation or ditching of the salt marshes.

Summer resorts situated in the woods or mountain districts distant from the sea may be troubled by woods' mosquitoes. These are never troublesome in the open, nor in houses not surrounded by trees. But persons visiting the woods for pleasure may be considerably inconvenienced by them, and in such houses as are closely surrounded by trees they may be annoying on the porches. Some eight to ten species are involved, all having similar habits, breeding in the early pools formed by the melting snow. The adults live some three months after breeding is finished, gradually diminishing in numbers throughout the summer. These mosquitoes may be combatted by filling or draining the hollows where the snow-water accumulates; but only in exceptional cases are the results worth the cost and labor of the operations.

The amount of personal annoyance caused by the house fly is of minor importance. The fly is quiet at night, and so does not disturb sleep. It does not bite. Its control, however, is most desirable, though not of the vital importance of the true disease-carrying insects. The control may be effected by proper sanitation of stables, protecting the horse manure from access by flies. While the house fly does breed in other substances than horse manure, this is its principal food, and treatment of this should prove effective. In combating insect-borne diseases, the extermination of the insect-agent is never necessary. Simply its reduction in numbers to a minimum where the general transference of the disease can no longer occur. The life of the parasite is conditioned on an abundance of both of its alternate hosts, and if either fails in numbers, it must cease to exist. The disease is then exterminated for that given locality

THE ALUMINIUM INDUSTRY

Although the early expectations of the wholesale substitution of aluminium for steel and iron have not, for very good reasons, materialized, it has shown such a perfect adaptability to certain of the arts that the demand for this metal has grown enormously. From a production in the United States of less than 100,000 pounds in 1883, in 1893 the output had grown to 350,000 pounds, in 1903 to 7,500,000 pounds and today it is in excess of 50,000,000 pounds. At the present time the use of aluminium in the place of copper has created a great temporary demand. New methods of reduction are being tried that promise a cheaper and more abundant supply.

THE DOCTRINE OF "FITNESS"

In his recent course of Lowell Institute Lectures, Prof. Lawrence J. Henderson of Harvard University discussed quite at length the subject of "Fitness." He brings to attention the fact that in general the consideration of fitness has been purely from the side of the organism, the suggestion being that organisms adapt themselves to the environment or that they survive when they are able to be in harmony with their surroundings. Professor Henderson looks at the other side of the Darwinian shield and in his initial lecture said "the hand fits the glove and the glove fits the hand; the bird fits the air and the air fits the bird. Fitness is mutual. In general a one-sided view is taken and it is the fitness of the organism to its environment that is most commonly argued, but the fitness of the world for life is as important as the fitness of life to the world." The series of lectures was devoted to pointing out the qualities in the world which make life possible and without which life as we know it would be out of the question.

The general line of the argument was that the earth is a fair sample of the universe. The discoveries of astro-physics show the universal distribution of the elements known to the terrestrial chemist and the inference is clear that other suns and other planets are all composed of precisely the same elements and these are subject to the same changes with which the earthly chemist is familiar.

Energy in like-manner is evidently not confined to the earth alone. These two facts provide for the speculative biologist a field in which material is furnished for an investigation of the relationship between life and environment.

Outlining the factors essential to life, Prof. Henderson pointed out that there are necessary a complexity in the life itself, a regulation of the conditions about it and third, food. It is not now possible to conceive of life that shall be truly simple for already in its lowest forms there is much complexity. If life is to persist there must be a durability of mechanism and this can exist only when inner and outer conditions are stable. It is evident then that the regulation of temperature, of pressure, and of chemical construction of both the environment and the organism itself are essential factors, which for convenience were classed under the one term, regulation. Then a living being must be active, hence, its metabolism must be maintained by means of matter and energy so there must always be an exchange of these with the environment. The question then comes, "given an organism to which complexity, regulation and food are essential to life, what are the conditions of environment which can best supply them?"

In the consideration of what conditions are essential for life, Prof. Henderson finds that the substances that will be most abundant on the surface of a planet with its crust formed are water (hydrogen and oxygen) and carbonic acid (carbon) and the greater part of his discussion was with reference to the peculiar fitness of these elements by themselves and in their combinations for the maintenance of life. Some of the arguments were that water has very nearly the highest specific heat of any substance and is most important in the production of the temperature of environment which if life is to be preserved must be free from cataclysmic changes. The likelihood of stability of temperature is greatly favored by the presence of water in the environment. Water, furthermore, is one of the greatest solvents, so that the ocean contains a greater variety of substances than if it were of any other substance than water. This affects the variety as well as the quantity of food. In the organism itself the solvent power of water makes possible the complexity of the blood in highly developed creatures and is the prime factor in certain organs in accomplishing their work. Then it is true that in the separation of oxygen from hydrogen, in the tearing apart of water, there is the largest amount of heat stored in the products and these two gases are uniquely

favorable to be reservoirs of energy, all of which is important to the organism. Without the preponderance of water the earth would possess its physical properties to very little purpose so far as life is concerned. The chemical stability of water is of great consequence in organic and inorganic processes. It is the principal constituent of all living organisms and is taken into the bodies of the organisms in far greater amounts than all other substances combined. Water makes the earth habitable by securing uniformity of temperature. Its high specific heat, the latent heat of vapor and the heat given out when water freezes are great factors in producing this uniformity.

Evaporation is a tremendous operation which through water is working for the needed uniformity of conditions. There is nothing to compare with water as a solvent and it is remarkable in its ionizing power. Aided by carbonic acid all substances yield to water, and rocks in place suffer a slow destruction. In this way there is set in motion the great earthly circulation of materials. Furthermore, water does not exhaust itself in its work.

Thus Prof. Henderson led to his general statement that "water by its very nature as it occurs in the operation of cosmic evolution has a fitness for life no less marvelous and varied than that fitness which has been one of the processes of adaption in the course of organic evolution."

The speaker next recounted some of the fitnesses of carbonic acid. "This," he said, "is so seldom separated from water that it is hardly fair to consider them apart. They are together the common source of every one of the complicated products which are made by living beings." Carbonic acid is all-pervasive, soluble and when in combination with water produces a liquid singularly inert to alkalis and acids. Through the latter quality the oceans are almost always nearly neutral. With its aid protoplasm and blood possess an unvarying reaction. As a whole, carbonic acid is less various than is water and its fitness not quite so obvious, but the two make a pair admirably and uniquely fitted to their mutual work by intricate relations.

These claims were supported by the review of observations in which Prof. Henderson has been engaged for half a dozen years and the chemical and physical properties of many other substances were noted. The outcome of the whole investigation is that the earth or any other planet would not be habitable but for the existence of just the conditions which are the natural result. There are so many qualities adapted to the environment of life that Prof. Henderson comes finally to the belief that there is not one chance in millions of millions that the many qualities and unique properties could occur simultaneously in the elements of hydrogen and oxygen which constitute water, and carbon, excepting through the operation of a natural law that connects them. He believes therefore that some unknown natural law must have been at work but does not himself consider what it may be, saying instead "the discussion of the question is more philosophical than scientific, it is open to anyone who may desire to enrich the subject with speculations of any sort. He may follow Prof. Bergson and call it 'impetus' or he may term it natural theology or he may take a teleological view. No such discussion can contribute directly to the scientific knowledge of the underlying phenomena." J. R. JR.

"HARDENED COPPER"

Metallurgists who have examined the so-called hardened copper of the ancients find that it is not pure copper but is generally a natural alloy and in some cases an artificial one made by melting two ores, copper and zinc, together. The Monel metal, now largely used in the arts, is made from the natural copper-nickel ore found in the Sudbury mines in Ontario and can be used for cutting purposes. In the vicinity of the Sudbury mines many ancient implements have been found made of this native ore hardened only by hammering.

The cutting implements of ancient origin having the appearance of copper, were once supposed to be of pure copper hardened by some unknown process.

INTENSIVE CONSERVATION IN JAPAN

Before the Appalachian Mountain Club, at a recent special meeting, Miss Ellen Churchill Semple spoke with reference to the effect of natural conditions on the people of Japan. She showed how the insular position forced upon the inhabitants enormous economy and intensive cultivation of the soil. "It is a fundamental principle," said Miss Semple, "that agriculture shall be highly developed in islands. They are bounded by the sea and since the farms cannot be extended into adjacent countries as on the continents, the art of tilling the soil is most highly developed." The limitation of area is not the only misfortune of this island empire but there are others of structure and soil that make agriculture difficult. In addition to the large infertile areas occupied by the mountain chains there are the beds of most of the rivers. These are comparatively short streams which drop in a quick course to the sea and have cut as yet only V-shaped valleys in which the banks rise at once from the water and there are none of the great bowl-shaped valleys on the floors of which agriculture is possible. The run of these rivers in general is so short that comparatively little land has been built up along the seashore from their detritus, but at the same time, it is on these small coastal plains that most of the agriculture has been developed. The nature of the upland country is such that there are no pasture areas for cattle.

Miss Semple presented in striking form the intensive quality of agriculture necessary to the Japanese people. Although the area of the islands together is 148,000 square miles, the conditions of infertility make all but fourteen per cent. of this useless, so that, as a matter of fact, the fifty-two million people of Japan must be supported from the cultivation of lands not greater in area than three times the state of Massachusetts. In addition to this, of course, there are the products of the fisheries. Japan, it is true, imports much food but it must be remembered that the payment for this comes really from the soil so that the maintenance of the people is dependent on the agriculture.

The result of these conditions is first that it makes vegetarians of the Japanese, for no cattle are raised and the absence of stock affords to the farmer nothing whatever in the way of barnyard supplies. It has been necessary on this account to make use of the wastes of the teeming population and to conserve everything in the way of inedible vegetable products so as to return the needed phosphorus and nitrogen to the farms. The savings towards the enriching of the soil are marvelous to one brought up in so wasteful a country as the United States, for leaves are hoarded, tree twigs, the straw of the cereals, the grass that may be cut for the purpose, and coming down to such matters even as the filtrations of the family bathtub. In the use of human wastes for fertilizing, according to Miss Semple, the people have known for ages the principles that the great governmental schools of Europe and America are just beginning to discover.

The view that was given by this speaker, who is the world's most famous anthropogeographer, is little short of wonderful, and impressed the audience with the constant back-breaking handwork in caring for the farms. Machinery is absent and animals are used generally only in the plowing of the land. It is hand labor everywhere and largely that of women. The soil is literally pulverized between the fingers. The weeding of the farms is a daily occupation and in the intensiveness of the work is made to include everything but the most perfect individuals of the crop itself.

The average farm is little above two acres in extent. The farmers live in villages to save the waste of land which roads to separated houses would entail, so that means of communication are by rough trails and paths. The villages are

THE SOCIETY OF ARTS OF THE MASSACHUSETTS INSTITUTE OF TECHNOLOGY

The Society of Arts was established as a department of the Institute by President Rogers in 1861. It is especially devoted to the general dissemination of scientific knowledge, and it aims to awaken and maintain an interest in the recent advances and practical application of the sciences.

Any person interested in the aims of the Society is eligible to membership.

The annual dues are $3.

RICHARD C. MACLAURIN, President of the Institute.
ISAAC W. LITCHFIELD, Secretary of the Society of Arts.

EXECUTIVE COMMITTEE

THE PRESIDENT
ELIHU THOMSON
JAMES P. MUNROE
THEODORE N. VAIL
ARTHUR D. LITTLE
FREDERIC H. FAY

THE SECRETARY

BOARD OF PUBLICATION

D. F. COMSTOCK
SELSKAR M. GUNN
ELLWOOD B. SPEAR
LEWIS E. MOORE

I. W. LITCHFIELD, Editor

SCIENCE CONSPECTUS is published December, January, February, March and April.

practically on waste land and from each village which lies in the valley of a stream there is the great untenanted forest stretching over the ridge into the valley beyond. There are places more particularly on the coast in which the fishing industries have congested the population, and agriculture is carried on on large terraces which extend at times even to the tops of the mountains.

Two or three crops are the rule and the practice of sowing the second one before the first one is harvested is common. There is no waste for fences since the country is without cattle, the divisions between fields and the ridges between the little inundated spaces of the rice paddies are filled with beans or some other vegetable that will help toward the feeding of the people and even with these provisions, the margin between ordinary life and actual starvation is very small, and an unfortunate season with cold or lack of rain may mean famine. In this whole agricultural scheme silk has come to be an important element and may even double the farmers' income. There is work here for the whole family including the children for six or seven months.

With this unending labor and so little in the way of comfort, the people are smiling and happy. Miss Semple's observations in Japan should mean a great deal to the people of the United States in which even with its three million square miles there is already discussed the question of conservation. In Japan with fully half the population, economic principles and conservation have been able to solve the principle of actual life from an area only half that of New York or Pennsylvania.

HIGH WIND VELOCITIES

No anemometers have yet been made strong enough to withstand the severest wind storms and probably the highest velocity ever recorded by an anemometer was 186 miles an hour on Mount Washington, on January 11, 1878. This was made by an instrument of the Robinson type and is probably much in excess of the true wind velocity. In the annual report of the chief signal officer for 1875 an attempt was made to estimate the velocity of the wind in a tornado that year, from some of its more remarkable manifestations; as for instance, from the fact that a pine board was driven through a telegraph pole and another three inches into a tree. To produce such an effect would require a velocity of from six to eight hundred miles per hour.

PROTECTING PUBLIC HEALTH IN SMALL TOWNS

Coöperative health administration is a plan for smaller communities which the Massachusetts Institute of Technology has devised and which is being put into actual practice. The furnishing of a health administration for rural communities, especially those adjoining one another, has been taken up regularly by the department of biology and public health as one of its public services and this the Institute proposes to furnish to the towns at practically its cost.

There are certain obvious advantages in a plan like this; in the first place there may be secured what is exceedingly difficult under any other conditions, the establishment of a proper and efficient health policy in adjacent towns and uniform health regulations. Adjoining districts thus working together can, by their united purses, secure for themselves a quality in sanitary officers to care for their work that would otherwise be absolutely impossible. They can secure an attention to important technical details, like the taking and testing of cultures. Coöperation in this way would be of great importance in the determining of an outbreak of infection. A case or two of some malady scattered in each of two or three towns would attract no attention but if these all came to the notice of a central officer, who has his eye on half a dozen such towns, the number of cases would suggest to him an outbreak and give to him the earliest possible chance to limit its spread through preventive means.

It is true that in some states such matters as these are under the care of the state board of health but, at best, such supervision must be rather distant and its effectiveness at critical moments lessened.

In the securing of a well qualified man, technically trained for the coöperative health work of a number of towns, the question of local jealousy will be no longer of any consequence. A single opinionated, stubborn practitioner will not then be able to dictate his health policy to the whole town and modern machinery carried on with the light of modern advances can immediately be applied.

When it comes to the details of running the health office it will be seen at once that there is a possibility of system in coöperation such as the individual town could never dream of and, so far as the expense is concerned, the divided cost of one good officer would impose on each town no greater burden than its present officer. In laboratory facilities more strikingly than in any other division, the advantage of having a central well-equipped establishment which may be almost instantly at the service of any town is beyond question.

The Institute has here originated a new and workable method of administrating public health in smaller places, applicable not only in Massachusetts where it has already been established but in all other communities desiring efficient health work. It is a beginning which has been watched closely for a number of months already, and the development of which will be of wide interest and importance.

A PRODIGY DUE TO DEFECTIVE VISION

A case is reported in the *Journal of the American Medical Association* of a man who had the power of reading a page of an ordinary duodecimo or octavo book at a glance. His eyes and attention were fixed on the book for a second or two and its statements or contents fixed in the memory.

The curious part of this is that this power of apprehension of a complete page was because of the loss of use of the central sensitive part of the right retina which had been destroyed by disease in middle life. The region about the destroyed spot increased its sensitiveness so much that it could clearly see all the border region of the printed page which to a person of clear vision, would appear blurred, owing to both eyes concentrating themselves upon a more or less fixed point on the page. L. E. M.

SCIENCE CONSPECTUS

VOL. III MARCH, 1913 No. 4

EARLY MAN*

THE STORY OF THE PHYSICAL DEVELOPMENT OF MAN FROM HIS EARLIEST RECORD AND OF HIS RELATIONS TO THE ANTHROPOID APES

BY HERVEY W. SHIMER

EOLITHIC

IT IS generally considered that earliest man is to be distinguished as man from other animals by the use of weapons and tools. With very primitive man these implements would be such casual sticks and stones as he chanced upon, and only later would follow a more and more careful selection of weapons better fitting the hand and more adapted to the use of defense and offense. Still later would it occur to man to improve this chance adaptability by the chipping off of inconvenient corners, so that the rounded ends might better fit the hands and the sharper edge perform more efficient service. To this slight alteration of stones, found ready at hand, would succeed the deliberate shaping of the flinty material into weapons and tools after a design existing in the maker's mind. And this first deliberate working out of a definite plan is taken as marking the first Paleolithic implement. To all the preceding stages of workmanship is applied the term Eolithic. (Fig. 1).

It is obvious that very low Eolithic culture would leave no incontrovertible trace of its existence. If, for example, the Semang of the Malay Peninsula were destroyed, one could not know of their existence from their stone implements; for since they apparently use only such as they chance to pick up these could not be distinguished from the other stones chipped by nature, which they had not used. Hence there has arisen much controversy among students of eoliths over the earliest geological time to which they may be assigned. Their occurrence in the Eocene is not now claimed but they have been found according to some students in the middle Oligocene of Belgium. More conservative opinion, however, recognizes no finds as true eoliths before those found in the upper Miocene of Cantal, France. According to the Belgian geologist Rutot, who has spent his life in the study of the Eolithic period, eoliths are found to be less and less shapely, as older and older deposits are searched, apparently showing evidence of less and less care in their selection by Eolithic man. So that it is possible before the period of transition from the Eolithic to the Paleolithic (Strepyan) to distinguish the descending series of Eolithic cultures,—Mesvinian, Mafflean and Reutelian. With this last period the eoliths are at their most primitive stage and all Tertiary eoliths belong to this culture period.

Up to the year 1907 these eoliths formed the only fully accepted evidence of the presence of Eolithic man. That year, however, parts of the skeleton of a

*Copyright 1913, by the Society of Arts, Boston.

man were found in the sand pit of Mauer, near Heidelberg, Germany, while on December 18 of last year announcement was made to the Geological Society of London of a similar find in a gravel pit at Piltdown, Sussex, England.

The Mauer, or Heidelberg man (Homo heidelbergensis) (Fig. 2) was found in stratified, undisturbed, early glacial sands at a depth of seventy-nine feet below the surface; the upper thirty-five feet of this consisted of a later glacial deposit (loess). Associated with the human bones (a lower jaw) were, to mention but a few, remains of the straight-tusked elephant (Elephas antiquus) characteristic of the lower half of the glacial period, an upper Pliocene to lower Pleistocene rhinoceros (Rhinoceros etruscus), and a primitive horse. These fossils thus demonstrate that it was during the early part of the glacial period that man and these now extinct beasts lived, and that the ancient Neckar river depositing here its loads of sand brought also these bones.

This jaw would be classed as anthropoid on the basis of the great width of the ascending branch with the very slight notch at its top, and the retreating chin, but the teeth are so small as to be distinctly human and they form an uninterrupted series, with the eye teeth not projecting above the surface of the rest.

By far the most important quite recent discovery of remains of early man is the so-called "Sussex man," Eoanthropus dawsoni (Fig. 2). This is represented by portions of a single skull, found in gravel of early Pleistocene age. The cranium capacity is distinctly human, being about twice that of the highest ape, but the indicated arrangement of the superficial arteries of the brain is typically simian, as is also the lower jaw. This last somewhat resembles the Heidelberg jaw, but is less massive, with smaller molar teeth and with a still more receding chin.

These two finds thus give us some conception of Eolithic man. They agree in presenting those most prominent primitive characteristics,—the almost entire absence of a chin and the presence of a massive lower jaw, and in combining other primitive, ape-like features with distinctly human ones. It is the present trend of opinion, likewise, to class with Eolithic man though possibly as a distinct race, the remains of the famous Pithecanthropus erectus—an imperfect skull, two molar teeth and a diseased thigh bone—found 1891–92. These occur in the earliest Pleistocene or latest Pliocene deposits in Trinil, central Java.*

Early man is thus associated with the lower Pleistocene in Europe. This period was marked by the repeated rise and fall of temperature, and geographical conditions were quite different from those of the present. The chief geographic feature was the continental elevation because of which lands now isolated were connected. There was no North Sea nor English Channel; Europe and Africa were connected both across the Strait of Gibraltar and across Sicily; France and Southern England were a continuous land mass, as were Ireland and the rest of Great Britain.

Paleolithic

Geologists agree that there were during the Pleistocene several glacial advances alternating with interglacial warm periods during which the ice retreated and the climate was in some instances even milder than that of the same latitudes at present. These alternations of climate naturally caused alternations in the plant and animal life, and thus for immense periods of time man of central Europe was associated with arctic forms of life and again for other immense periods with temperate forms.†

It is usually considered that there were in central Europe four periods of cold—of ice advances, and three periods of milder climate—of interglacial ice re-

*According to Schuster (1911) the fossil plants from these beds, brought back by the two Selenka expeditions of 1906–1907 and 1908, are of lower Pleistocene age.

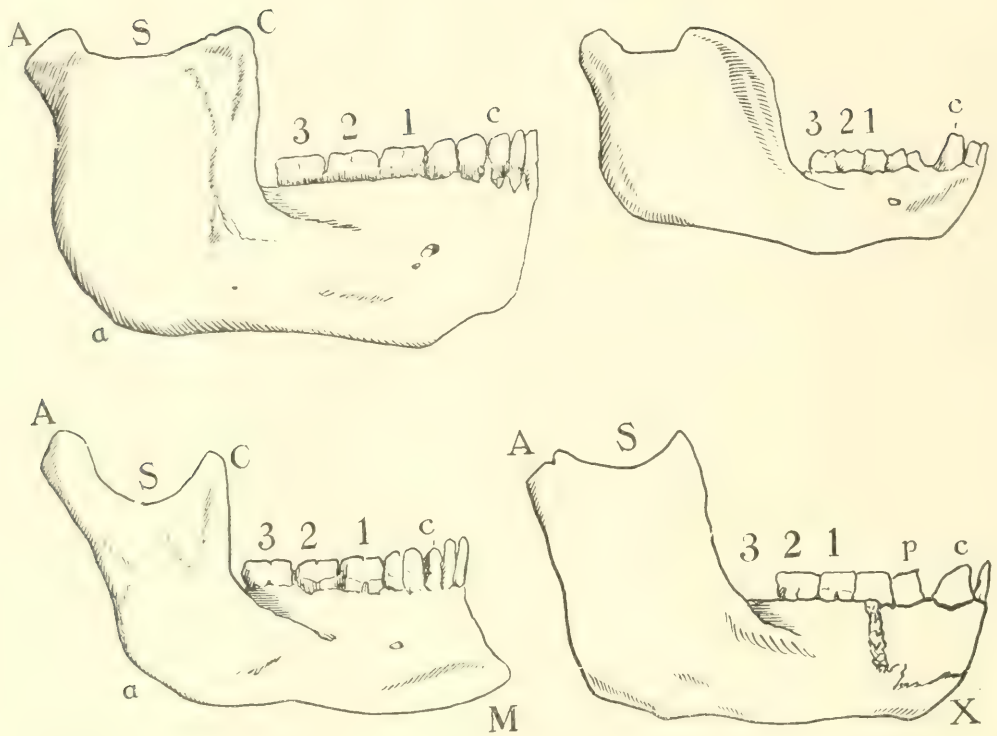
†It has been suggested that as the modern anthropoids live entirely upon fruits and vegetables so likewise did early man and that for Europe at least the change from such a diet to one of mostly meat was due to the killing off of the tropical vegetation because of the advance of glacial conditions. Man would thus be forced to adopt more and more an animal diet.

Figure 1—A. Eolith, Mafflean Culture Epoch, Belgium. B. and 1. Paleoliths, Chellean Epoch; the former from Kent, England; the latter from Chelles, France. 2. Paleoliths, Acheuilian, France. C. Neolith, Denmark. (A, B, C after MacCurdy from Osborn; 1, 2 after de Mortillet from Hoernes)

treats. During the first two of these ice advances and their included interglacial period, man was in the Eolithic stage of culture. And thus it was not until the middle Pleistocene that the existence of Paleolithic man is first recognized.*

The finding of certain human skulls in the upper Pleistocene finally established the former existence in Europe of another human type so different from both Eolithic and modern man as to be considered a distinct species. This is the Neanderthal man, or Homo primigenius (Figs. 3, 4). Perhaps the two most famous specimens of this type are the Neanderthal man and the man of Spy. The former consists of a human skull, associated with no implements, which was found in 1856 in a cavern near Düsseldorf, Germany. Its stratigraphic position and hence its geological age were somewhat doubtful. Later finds, however, in stratigraphically well assured position showed the same primitive characters as this Neanderthal skull and accordingly it has given its name to the type it represents. At Spy, near Namur in Belgium, two skeletons were found associated with the remains of the mammoth and with implements of a certain type, the Mousterian. Many other skulls and a few more or less complete skeletons found especially in caves of France and Belgium combine in giving us some conception of the appearance and capabilities of this Neanderthal man; the

* Except for his implements there are no undoubted remains of man from the Mesvinian to the Acheuilian inclusive.



A Comparison of Jaws. Figure 2—A. Articular condyle to hinge jaw to skull (in glenoid fossa); at its anterior edge are attached the muscles (external pterygoid) mainly responsible for moving the jaw forward and sidewise. C. The process (coronoid) for the attachment of one of the muscles (temporal) which brings the lower jaw with force up against the upper; the other muscles aiding this are the masseter (attached to the angle (a) and ascending branch) and the internal pterygoid (attached to the angle (a)). S. The sigmoid notch at the top of the ascending branch of the jaw grows deeper as the jaw becomes lighter. c. The canine tooth projects above the level of the other teeth in the anthropoid and is also separated from the first premolar (p) by a gap (diastema). This latter may have been true in the Sussex man. 1, 2, 3, first, second, and third molar teeth. The Sussex jaw (Eoanthropus dawsoni) has been restored from the broken line (X) to the tip of the jaw after Lankester in the *London Daily Telegraph*.

From left to right the jaws are,—(upper row) Heidelberg man, Chimpanzee; (lower row) modern man, Sussex man.

various weapons and tools found associated with these remains indicate something of his state of culture and manner of life, and the remains of animals in these same deposits enable us to understand the climatic conditions to which he was subject.

The skull is especially remarkable in its very low, flattened forehead and long backward extension, in the very prominent eye-brow ridges joined over the nose, and the large eye cavities and nasal opening, in the retreating chin and in the massive character of the lower jaw (Figs. 3, 4). The notch at the top of the ascending branch is almost as shallow as that of the Heidelberg jaw.

Such an extremely low forehead leaves little room for that part of the brain which is associated with higher mentality, such as the power of association of ideas. Hence we may assume this man as possessed of little power of memory and inference and perhaps without much capability of articulate speech. The large space at the back of the skull for the lodgment of the optic lobes should indicate a well-developed power of observation. The limb bones are massive, with the thighs (Fig. 5) and upper shin bones curved, suggesting the peculiar gait supposed to have been characteristic of the Neanderthal, that is, a somewhat stoop-

A B

Figure 3—A. A skull of the Neanderthal man (Homo primigenius) from Le Moustier, France. B. Skull of a native Australian. These agree in the very slight forehead, strong eye brow ridges uniting across the nose, face strongly prognathous, wisdom tooth largest of the molars (in Europeans it is the smallest or wanting entirely), principal chewing muscle (temporal) very large as is shown by the strongly impressed area for its attachment from the strong temporal ridge (X) down to the coronoid process (C). The brain of the former was the larger. Sollas (in "Ancient Hunters") looks upon the Australians as the degenerate descendants of the Neanderthal race, though somewhat mixed with other blood. A, after Hauser, from MacCurdy; B, after Klaatsch from Buttel-Reepen)

ing gait with the knee joint not straightening completely at each step. His height was about five feet, three inches.

Nearly all of the skeletal remains of Homo primigenius are found in association with one type of weapons and implements, named the Mousterian from its abundant occurrence at Le Moustier Cavern in southern France. Two typical implements of this type are the side-scraper and the Moustier point. This side scraper is especially characteristic of the Moustier industry, chipped on one face only and with a curved scraping edge, opposite which is generally left part of the original surface of the flint to serve as a grip.

It is supposed that through the long ages man gradually evolved this implement from the eolith. Several transitional types are recognized and named—the fact that they are transitions being shown by their form and workmanship and in many cases by their intermediate stratigraphic position. This evolution is well displayed for example in the famous site of St. Acheuil, a suburb of Amiens, France. Pits dug in deposits of clay and gravel along the river disclosed a succession of strata containing a succession of implements from Eolithic types up through the Paleolithic and into the Neolithic. Thus the lower gravels contain the coarsely flaked type of implement to which the term Chellean has been applied, the middle gravels contain Acheuilian, more finely flaked implements, and the upper gravels and brick earth, Mousterian types grading up into Neolithic implements.

In some other localities a Strepyan stage has been recognized which still earlier than the Chellean showed the deliberate flaking for the making of a weapon which characterizes the first Paleolithic weapons in contradistinction to the eolith, which man used as a weapon either just as he found it or with at most some slight chipping off of inconvenient angles.

Our knowledge of the climate of central Europe during Paleolithic time and of the environment against which these early men struggled and to which they had to adapt themselves is based largely on the remains of animals found in association with these human remains and implements. Thus we know the Chelles period of the early Paleolithic was a time of warmth. Man probably lived in some part at least upon wild fruits and roots and likewise hunted various small animals as well as the mighty straight tusked elephants (Elephas antiquus) and the broad nosed rhinoceros (Rhinoceros mercki) which during the middle Pleistocene roamed over central Europe. As man possessed no very efficient hunting weapons at this time, he probably captured these huge animals by means of pitfalls. The fauna of this stage as a whole is that of forests, river borders, and open meadows.

The warm climate of the Chelles period is further evidenced by the plants found in these mid-Pleistocene strata. Figs and the sweet bay flourished and a species of ash now found in Italy and Corsica.

To the many centuries of the Chelles period there gradually succeeded a colder climate. The animal and plant forms of the warm forests either died off or migrated into other regions and their place came to be taken by the life of grassy, treeless steppes. Man's implements at this time have developed into what is known as the Acheuilean type. They are more carefully and sharply pointed than the Chellean and more finely chipped. (Figs. 1, 1 and 2.) The colder climate of this Acheuilean epoch finally culminated in the glacial conditions of the Mousterian epoch, a term again introduced from finds in a cave in France. The grassy steppes have become impoverished mossy plains or tundras, the straight tusked elephant (E. antiquus) is no longer found north of Italy and the broad-nosed rhinoceros has likewise disappeared. The number of food plants grows less and less and man lives more and more by the hunt—upon the wild horses of the steppes, the mammoth (Elephus primigenius) (Fig. 6.) and the reindeer. The fact that man at this time lived largely in caves and rock shelters is another indication of the cold climate.

Slowly man learned to carve the bones, teeth and horns into implements of use and beauty. In the Mousterian for the first we find pointed implements for boring holes. To this epoch belong most of the skeletal remains of the Neanderthal man thus far found. Many caves, especially in France and Belgium, have yielded such remains, either as skulls or at times as several more or less complete skeletons. In the cave of Le Moustier in France the body had been laid in a position of ceremonial burial with his head resting on a flint plate of careful workmanship. Other conditions are shown by the skeletons found in the pit of Krapina in Croatia—a pit now filled with glacial sands but which was once in the bed of a brook now many feet deeper. The remains were of about ten individuals of different ages and the shattered and burned condition of the bones is held to indicate that they are the relics of a cannibal feast.

The Mousterian, according to Penck corresponds to the third glacial advance, the most extensive ice invasion known; to it after a short interglacial period succeeded the fourth and last great glaciation of the old and new worlds, including in its advance, maximum and recession the three last stages of Paleolithic culture. This upper Pleistocene time is the period of the reindeer (R. tarandus), of the giant woolly rhinoceros (Rhinoceros tichorhinus) and of the arctic, woolly mammoth (Elephus primigenius); the musk ox (Ovibos moschatus) returns and there are large herds of reindeer, driven south by the advance of the ice sheet over northern and central Europe, the reindeer penetrating even as far south as Spain. The name of tundra fauna has been given to the fauna of the time of greatest glaciation, characterized by the musk ox, reindeer, arctic hare and arctic fox, etc. It has been definitely proved by the geologic deposits at several different points that this fauna was followed by a steppe fauna. The reindeer, rhinoceros and bison roamed freely, wild cattle (Bos

A B

Figure 4.—A. The La Chapelle man, a primitive representative of the Neanderthal race, compared with B, a European. Note in the latter the prominent forehead, nose and chin, the weak eye brow ridges and teeth, and the lighter build of the lower jaw. (A, after Boule from Buttel-Reepen; B, after Buttel-Reepen)

primigenius), wild horses (close kin to the existing E. przwalskii of Russia), and antelopes, grazed on the plains. Certain drawings on the walls of caves inhabited by upper Paleolithic (Magdalenian) men depict this horse of the steppes. Such animals are still found in the steppe regions of northern Asia.

The culture stage succeeding the Mousterian is termed the Aurignac from a locality of implements in southern France. The characteristic implements are points and scrapers of chipped flint with which wood and bone would be worked, bone needles and spear points, often forked at one end for the attachment of a haft. To this period likewise belong the first truly artistic attempts. Tiny human figures are carved out of ivory or stone, and the paintings on the walls of some caves belong probably to this epoch also.

Next succeeded the Solutrean; this stage of culture is typically represented at Solutré in eastern France, where was a Paleolithic open-air camp. Fragments of about 100,000 horses, mingled with the bones of other animals of the chase formed a sort of rampart around this camp. This was the forest type of horse, a short-limbed pony, with teeth and hoofs adapted to life on the low-lying ground in the vicinity of forests. There is no evidence that man reared these animals for food or other use. This was the acme of the Paleolithic working of flint, characterized by finely chipped lance heads, mostly of laurel leaf shape and with a notch for the attachment of a haft. Sketches were made on reindeer horns and bas reliefs were carved from them. Of course it is probable that mammoth ivory and reindeer horn, the bones and teeth of animals and bits of stone were not the only materials that man carved and adorned with his flint knives. But such other materials as wood have not been preserved.

The Paleolithic closed with the Magdalenian—so named from the cave of La Madeleine in Dordogne—the period of the last glacial retreat. The fauna takes on a more and more modern aspect until at its close we find practically no more remains of entirely extinct animals. That the climate was still cold is indicated by the figure of a glutton carved on a bit of bone from a Dordogne cave and by the remains of some northern varieties of moss. Reindeer antlers are carved with engravings of various animals. Flat stones are painted with red and black simple designs of points and lines; tiny human figures are carved out of ivory. Sketches of the mammoth, the horse, the bison and the Saiga antelope adorn the walls of caves of this period. Birds are

represented by the swan and the wild goose, fishes by trout, pike and salmon.

Wall sketches (Fig. 6.) have already been found in twenty-seven caves of southern France and northern Spain. It has been suggested that the fact that nearly all of the animals pictured were useful to these hunter and fisher folk may be explained as the use of a sort of magic. It is a common primitive idea that the possession of a picture gives power over the object pictured and thus would make easier the capture of food animals.

Though Homo primigenius, the Neanderthal man, is the human type specially characteristic of the lower Paleolithic, skeletal remains in certain cave deposits indicate that at first contemporary with him and gradually displacing him in the upper Paleolithic lived another type of man so different as to constitute another species.

This type, far more advanced than Neanderthal man, is Homo sapiens, the species of modern man. Specimens of this type in this remote Paleolithic time, display the modern characteristics of high, vertical forehead, reduced eyebrow ridges and projecting chin though naturally to a less advanced degree than in the modern European. Several types of this advanced species have been found in the cave deposits of Europe. Among them are a supposed Negroid race, the Grimaldi, and a tall, stalwart race, the Cro-Magnon, with an average height of at least six feet.

The cave of Cro-Magnon is in a limestone cliff overlooking the valley of the Vezere near Dordogne. It was discovered in 1868 and in it the skeletons of two men and a woman; with the human remains were found worked antlers of the reindeer and remains of the horse, mammoth, cave lion and cave bear. A few other Paleolithic cave finds in France reveal the same type of skull and indicate remains of this same Cro-Magnon race. These finds are mainly assigned to the Magdalenian period. The skull of these precursors of modern man is characterized by a high forehead, reduced eyebrow ridges, great cranial capacity and a slightly projecting chin.

That this superior type may have existed side by side with the Neanderthal in yet earlier Paleolithic times is indicated by the Galley Hill specimen, found in ancient river gravel near Northfleet in Kent in association with implements of Chelles type. The skull has a comparatively high, convex forehead with eyebrow ridges not exaggerated. It is considered as representing a superior race, quite distinct from the Neanderthal, which existed even in these early Paleolithic times and developed into the Cro-Magnon type of the later Paleolithic.

An even earlier beginning of this superior race may possibly be shown in the finding in 1911 of a skeleton of this type in Ipswich, England; the glacial deposits in which it was found are provisionally assigned to the Mesvinian, the latest Eolithic horizon.

One of the more interesting of the theories proposed to account for the existence of these two distinct species side by side in the Paleolithic is that man had a diphyletic origin. According to this hypothesis of Professor Klaatsch, the Neanderthal man and the African anthropoid apes, the gorilla and the chimpanzee, diverged in the far distant past from a common ancestor and on the other hand, the upper Paleolithic and recent man is more nearly allied to the Orang-utang, springing from a common ancestor with this Asiatic anthropoid. According to this theory, the more primitive Neanderthal man first entered Europe from Africa, while a later invasion from Asia introduced the higher Homo sapiens.

However the origin of the two types be accounted for, the beginning of the Neolithic or possibly the upper Paleolithic must have found the Neanderthal man either extinct or at least vanished from Europe.

Neolithic

As the great glacier invasion slowly retreated north and northern Europe became depressed, the climate became more humid and reforestation set in—thus began the era of modern forest-dwelling animals and of Neolithic man.

Enormous intervals of time must have been consumed in this successive peopling of central Europe by the fauna of the tundra, of the steppe, and of the forest. Only slowly were the steppe mammals driven by the increasingly damp climate toward the east to make room for the forests and their fauna. It has been shown that the large herbivorous animals, because more closely bound to their special environment were the principal migrants. Carnivores could more often continue from one climatic period into the next. The horse, likewise, continued through steppe times into the forest period, through the migration of special types fitted to these habitats—thus we can distinguish steppe and forest types of horses. The reindeer also was found in the forests of Germany after the time of Caesar. But in general the country of Neolithic man was filled with a changed fauna, which included the common squirrel, red deer, moose, red fox, wild boar and brown bear. This Neolithic fauna is the direct descendant of preceding faunas; no new mammals except those introduced by man appear from other regions to take the place of the now extinct mammoth, woolly rhinoceros, cave bear and cave lion and the highly specialized tundra and steppe types which have been forced to retreat to the north and northeast.

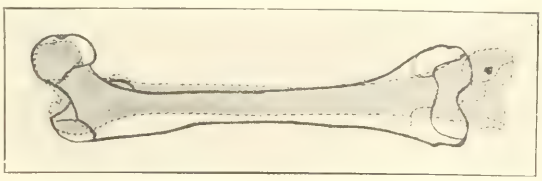


Figure 5—Thigh bone of a Neanderthal man (in outline) compared with that of modern man (shaded). The ends of the former are larger, giving big clumsy joints at knee and hip; the shaft has a marked bend forwards in the middle, so that he could not completely straighten his legs at the knee-joint but always kept them slightly bent in walking or standing. The shaft, likewise, is much wider from side to side than from before backwards while that of modern man is almost a perfect cylinder (after Keith)

We find at the dawn of Neolithic civilization in Western Europe a primitive people living largely on shellfish, as well as the produce of the chase, and fruits, roots, etc. They probably were somewhat assembled into communities but they had at this time only rude implements of stone, bone and horn. It is supposed that the dog was domesticated about this time by the Neolithic men of the Danish kitchen middens.

In certain caves of western Europe the remains of the Paleolithic and Neolithic periods are separated by layers of stalagmite which must have taken an immense period of time to form. Certain other settlements show by their cultural remains uninterrupted habitation from Paleolithic into Neolithic times. It has been suggested that while some of the old settlements of Paleolithic time were abandoned and whole communities followed the retreating reindeer to the north, a part of the ancient population still lived on in western Europe, finally amalgamating with new comers who in a constant stream of immigration brought a new culture from the east. On this theory the two industries of ivory and bone working and of the flaking of flint for a time existed side by side, and while the flint industry developed new forms in the Neolithic times, the working of ivory and bone gradually died out with the disappearance of the mammoth and reindeer. At any rate it is supposed that a new culture from the east gave European Neolithic man the art of polishing stone and of geometric ornament. Wheat, barley and millet were introduced from the Orient and agriculture became more and more important. The people became less nomadic, living mostly in villages of half underground huts,—a type of habitation that spread all over Europe and persisted for centuries.

This epoch was preëminently influenced by the domestication of animals. The successor of Paleolithic man possessed the sheep, goat, hog and ox as well as the dog. He captured and domesticated at least three indigenous European

species, the forest horse (Equus caballus typicus) and the Celtic pony, a plateau type (E. caballus celticus), and the Celtic short horn cattle (Bos longifrons). He hunted the wild ox (Bos primigenius), the urus of Caesar which survived in Germany until the twelfth century. His domestic ox (Bos taurus) is descended from an Italian Pleistocene form and hence was probably an inheritance from the east along with the sheep, goat and hog.

The wonderful skill of the cave men in delineating animals was not handed on to the new stone age but the principal attention was given to the flaking and polishing of flint implements. The methods adopted by Neolithic man for extracting flint are illustrated in several ancient flint mines in England. These early miners excavated shafts in the chalk rock to depths of ten to forty feet and from the bottom of the shafts tunneled galleries following the seams of flint. The implements they used in this work were picks of red-deer antlers and rude flint tools. Some of the galleries are nearly thirty feet long. Hence they were probably artificially lighted—perhaps cups cut out of chalk such as have been found in some of the mines served as these primitive lamps. Such mines exist in Norfolk and Sussex in England and in Mons, Belgium.

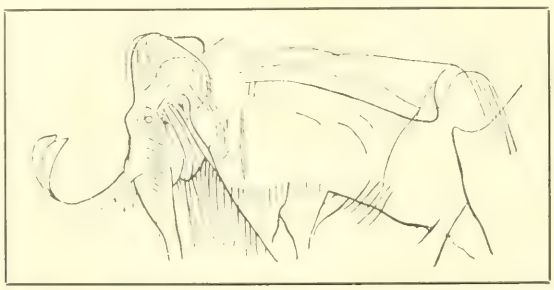


Figure 6—The hairy mammoth (Elephas primigenius) engraved on ivory, from the rock shelter, La Madeleine, France. It belongs to the Magdalenian culture epoch. It faithfully portrays all the striking characteristics so well known to us now through the well-preserved animals from the frozen soil of Siberia; the profile of the head, curving tusks, small eye, large mouth and long hair are all shown (after Lartep and Christy from Sollas)

The earlier lake dwellings and kitchen middens of Europe are of this period.

It is probable that man's appearance has changed very little from Neolithic times to the present. (Fig. 9.) The teeth of Neolithic people are usually much better preserved and more regularly placed than in modern man. It has been suggested that the method of mastication has altered, since in Neolithic man the incisor teeth at rest meet edge to edge, allowing a freer sidewise grinding movement and a more regular wearing down of the crowns. One other skeletal difference is the flattening of the shin bone (tibia) in contrast to its prismatic section in modern races,—a feature possibly connected with changes in posture and gait.

But in stature and form of head, specimens of the Neolithic men of England are nearly or quite like some types of modern Englishmen. Yet such a specimen, the Tilbury man, for example, was found in the Thames valley beneath 31 feet of strata, thus showing the presence of this modern-appearing Neolithic man when the river flowed in a channel more than 30 feet below its present level. Such an extended interval of time,—variously estimated at from 15,000 to 30,000 years,—as would be consumed in bringing about this change in the Thames valley, indicates the extreme slowness with which man's physical characters have changed.

Estimates of Time

There have been various estimates of the time in years that was consumed by this slow evolution of man's physical form and intellectual powers. Estimates of the length of the Glacial period vary greatly. For example the climax of the fourth or great glacial advance is placed by various students of the Pleistocene at from 20,000 to 60,000 years ago. The length of the entire Glacial period (Pleistocene) is estimated as 100,000 years

Figure 7.—A painting of the hairy Mammoth by Knight (from Osborn)

by Upham, 400,000 by Sollas, and 500,000 to 1,500,000 by Fairchild; while Penck believes that the whole Ice Age lasted somewhere between 500,000 and 1,000,000 years and he reckons that 30,000 to 50,000 years have elapsed since the climax of the last glaciation. So according to Penck the last of the Paleolithic period was perhaps 16,000 years ago, while the man of Heidelberg lived 500,000 or perhaps a million years ago.*

Compared with the length of the Paleolithic, the Neolithic and the later metal periods are of insignificant length for it is estimated that the beginning of the age of metals dates back three thousand to three thousand five hundred years in central Europe.†

* The following are some of the modes of estimating geologic time;—(1) Comparison of present rate of accumulation of sand and mud on a delta, etc., with the total thickness of such rocks. (2) Comparison of the present rate of the wearing away of land with the total amount of such erosion in the past. (3) Comparison of the rates at which present glaciers move forward and retreat, with the total amount of such movement in the past. (4) Chemical content of the sea. (5) Astronomical changes. One method of estimating mode (2) is the "cedar-root chronology" evidently invented by James Hall in estimating that a certain mastodon (of late Pleistocene Age) in New York State was deposited by the stream at least 35,000 years ago. Knight used this method in working out the time necessary to erode a vast depression in Wyoming, known as Bates-Hole. Many pine trees grow upon its slopes; these have the ground removed from their roots to an average depth of three feet. By cutting down some of the trees and counting the number of concentric rings (a ring to a year) it was found that they had an average age of 300 years. Hence one foot was eroded in 100 years. Three miles have been eroded; but before erosion began Miocene beds had been deposited, hence erosion did not begin before the beginning of the Pliocene. So according to this estimate, 1,584,000 years have elapsed since the beginning of the Pliocene time. One method of estimating mode (1) is that of de Geer, who, maintaining that the greater melting of the glacier front during summer would produce a layer of mud over the land before it, has counted 5000 such layers in Sweden; making thus the time occupied by the retreat of the last glaciers over Sweden alone 5000 years.

†The beginning of Egyptian civilization is usually placed near the beginning of the Neolithic period; but this as well as those of Assyria and Babylonia had reached the Iron period while Central and Northern Europe was still in the Neolithic.

In North and South America most conservative geologists hesitate to assign man's earliest presence on these continents before the close of the Glacial period.

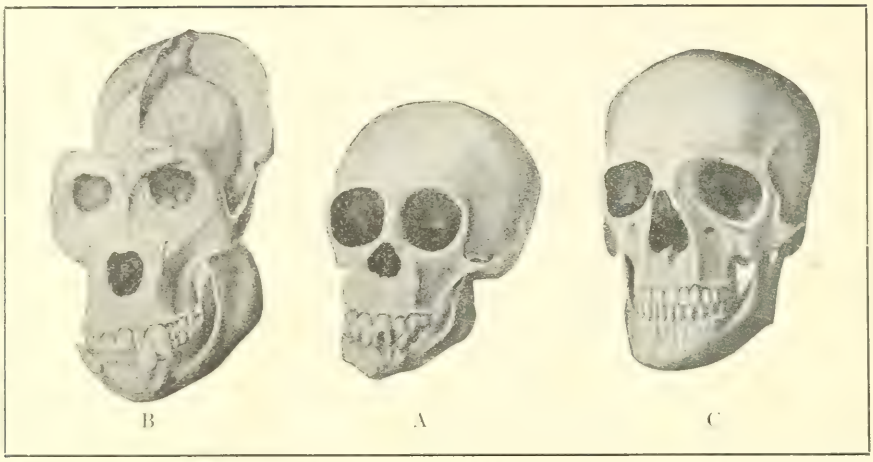


Figure 8.—Comparison of the skulls of the young gorilla (A) with the adult gorilla (B) and adult European man (C). Compared with the adult man (C), the skull of the adult gorilla, (B), (as well as the other anthropoids) shows degeneracy from that of its own youth (A) in the reduced forehead, the greatly increased massiveness of the lower jaw, the wonderful reduction of the chin and in the great development of the eye-teeth. The heavy ridges (sagittal and lambdoidal crests) projecting upward and outward from the skull of the adult gorilla are associated with the greater development of the temporal muscle in closing the jaws; they are absent in the female (from Buttel-Reepen)

Comparison with Living Races

We find living in the world today all stages of culture from the Eolithic Semang of the Malay peninsula with apparently only such stone implements as they chance to pick up, through the very primitive Paleolithic of the but recently extinct Tasmanian aborigines, with knives chipped on one side only, and the higher Paleolithic of the Australian aboriginees,* the Veddahs of Ceylon, south African Bushmen,† Tierra del Fuegans and Esquimaux,‡ through the Neolithic culture of the natives of New Caledonia to the highest types of modern material advance. This complexity may on the one hand be explained on the same line as the present complexity of organic types; for example bivalve shells first appear in the lower Paleozoic, fish in the middle, and reptiles in the upper Paleozoic, but all continue living to the present; the higher type does not destroy the lower.* So the Eolithic culture may have appeared first, next the Paleolithic and

* See figure 3 B.

† Sollas, in "Ancient Hunters," suggests that these Bushmen are the present day representatives of the Paleolithic Aurignacians. Their skulls closely resemble each other in all respects and they similarly inhabit caves whose walls they very artistically decorate with monochrome and polychrome paintings. They likewise throw their kitchen waste in heaps,—at one place the Bushmen had thrown several hundred skulls of gnus in a single heap, as at Solutré paleolithic man had similarly collected the bones of the horse into a heap over 300 feet long by 10 feet high. Evidences of Bushmen are found over much of South Africa though at present they inhabit only the Kalahari desert.

‡ Sollas, in "Ancient Hunters," suggests that the present day Esquimaux are the direct descendants of those Paleolithic Magdalenians represented by the Chancelade skeleton. They are both of short stature, are orthognathous and indeed similar in every feature of the skull, including the peculiar keel-like appearance (from front to back) of the top of the skull. They are similar in their culture; both are most artistic in sculpturing figures in the round. It is suggested that as the reindeer followed the melting glaciers northwards the Magdalenian race followed their chief source of food;—the reindeer, probably by way of northern Asia since the old land-bridge by way of Iceland had broken down in the Miocene or Pliocene). Magdalenian man, a hunter, was probably urged in his northward migration by the spread of Neolithic man, a farmer. Agricultural people are always more numerous than hunters; since about a thousand of the former can subsist on the same amount of land as one of the latter, hunters must always give way to the superior numbers.

*See figure 12.

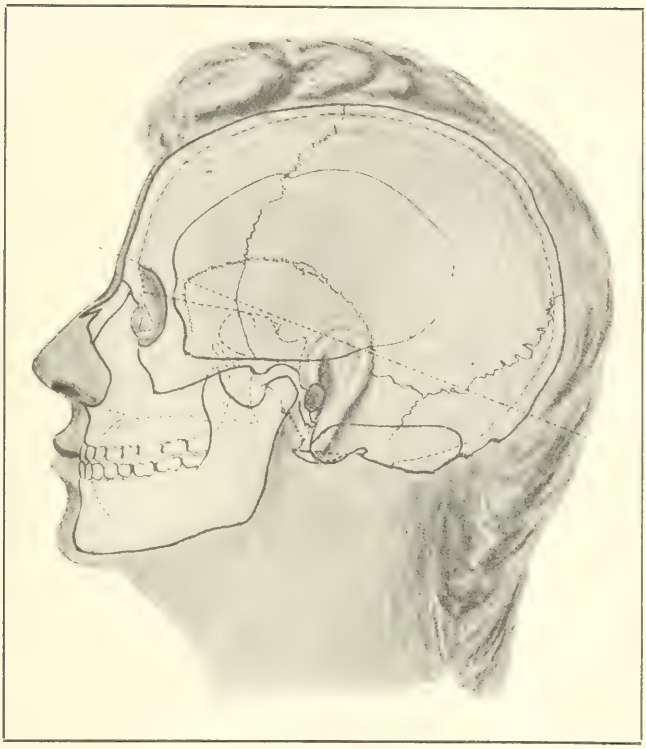


Figure 9—A late Neolithic skull (the Essex woman) from the east coast of Essex, England. The relation of the soft to the hard parts is indicated. Note on the skull the the high forehead, long bridge of nose and slightly projecting chin (after Keith).

finally the Neolithic; but the lower cultures continue to exist in remote regions.* On the other hand, there is strong evidence in fossil remains, language, etc., that many of the primitive peoples have degenerated from a higher civilization. The evidence at present, however, apparently indicates that in Europe, at least, there occurred a development from the Eolithic, successively through the Paleolithic, Neolithic, bronze and iron culture periods. Thus in Europe undoubted eoliths are recognized from the Pliocene and lower Pleistocene, paleoliths from the middle and upper Pleistocene and neoliths from its close. The skeletal remains of man point to a similar conclusion; the most primitive type with the very heavy jaw, chin strongly retreating, and retreating forehead occurs only in the lower Pleistocene; with the mid-glacial times a higher type occurs—the low-browed Neanderthal race. Thus according to the cultural and skeletal evidence now at hand the modern European man has developed from a primitive type approaching the existing higher apes in physical characters; and it should be remembered that among living races it is those with the lowest degree of culture, as the Veddahs of Ceylon and the Australians, who possess the most ape-like physical characters.

Comparison with the Anthropoids

It is the belief of most workers along this line that modern man and the modern higher apes or anthropoids (Chimpanzee,

* "Many of the savage races still surviving are merely side eddies of an earlier stream of culture through which civilized races have passed." Robert Munro, "Paleolithic Men." p. 24. (See figure 13.)

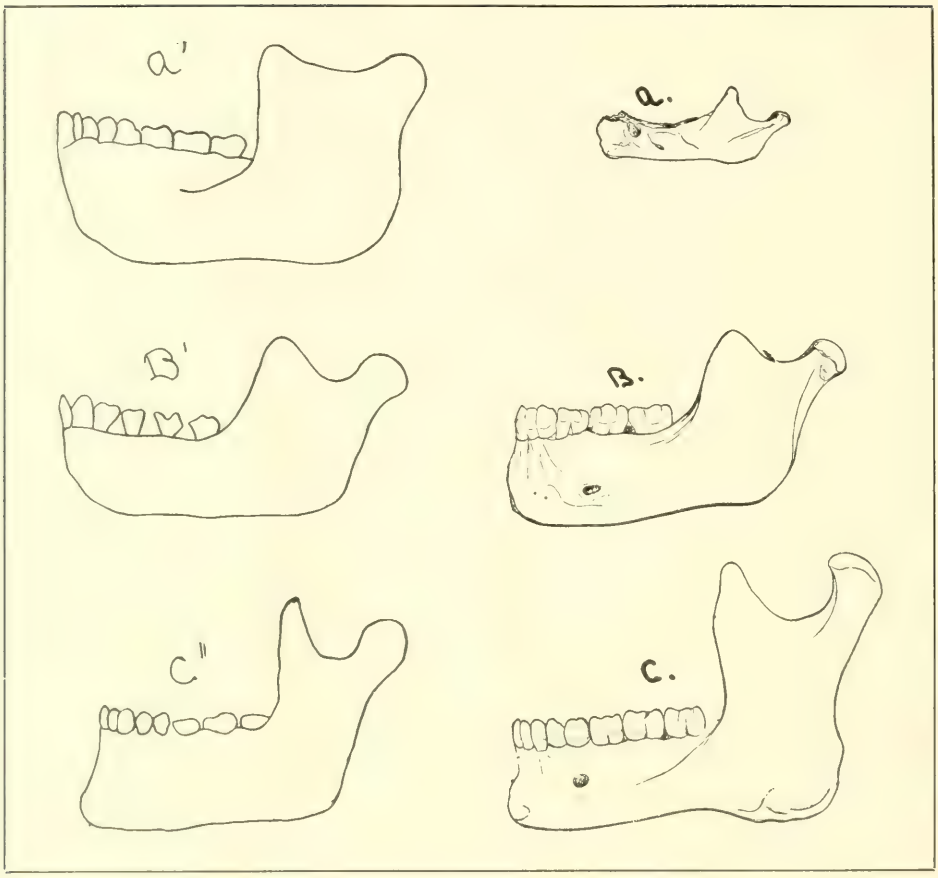


Figure 10.—A series of the modern European jaws from birth through adolescence to adulthood compared with a series of adult jaws of early man. At birth (A) the jaw is similar to that of the adult Eolithic man (A', Homo Heidelbergensis) in its strongly retreating chin and broad ascending branch with a shallow notch at its top. At adolescence (B) the jaw has become like that of the full grown lower Paleolithic (Neanderthal) man (B', LeMoustier man) in its almost vertical chin and its still broad ascending branch with the shallow notch. At adulthood (C) it is similar to the jaw of Neolithic man (C', Essex man) in its projecting chin and its narrow ascending branch with the deep notch at its top. For these features in a later man (see Fig. 4, B). (A, B, C, from Gray's Anatomy; A', B', C', tracings; A', reduced after Schötensack and MacCurdy; B', after Hauser's Le Moustier skull; C', after Keith's skull of the Essex woman)

Gorilla, Orang-Utang and Gibbon) have diverged from some common ancestor, or ancestors. If this is true we should then expect to find certain resemblances between them and especially should these resemblances be more marked in the young than in the adult (Figs. 8, 11).

To mention but a few of these similarities—the young anthropoid's skull has a more distinct forehead than the adult, indicating thus a degeneration in the latter; the brain convolutions of the child are much simpler than the adult, approaching that of the anthropoid; so likewise the child's nose and more especially that of the foetus is short and broad like the ape's but with age the bony bridge of the human nose grows higher and longer. The milk teeth are more like those of the young anthropoid than are the permanent set; this is shown in the relatively higher and broader crowns of

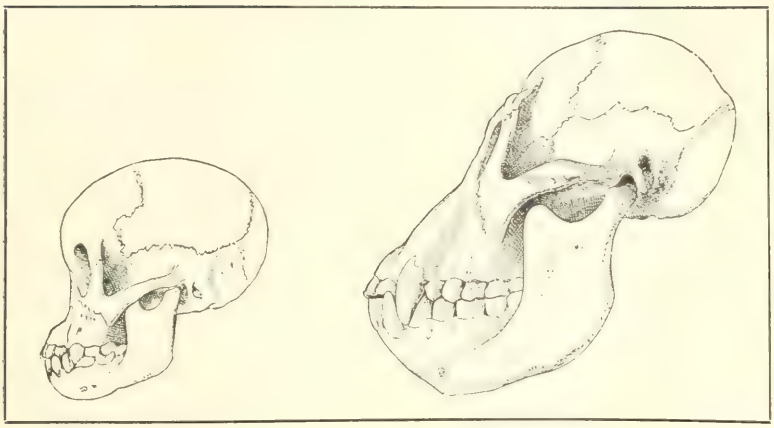


Figure 11—Compared with man the adult Orang-Utang shows degeneracy from its own youth in its reduced forehead, greatly increased massiveness of the lower jaw, reduction of chin and enlarged eye teeth. Both one third natural size (after Wiedersheim)

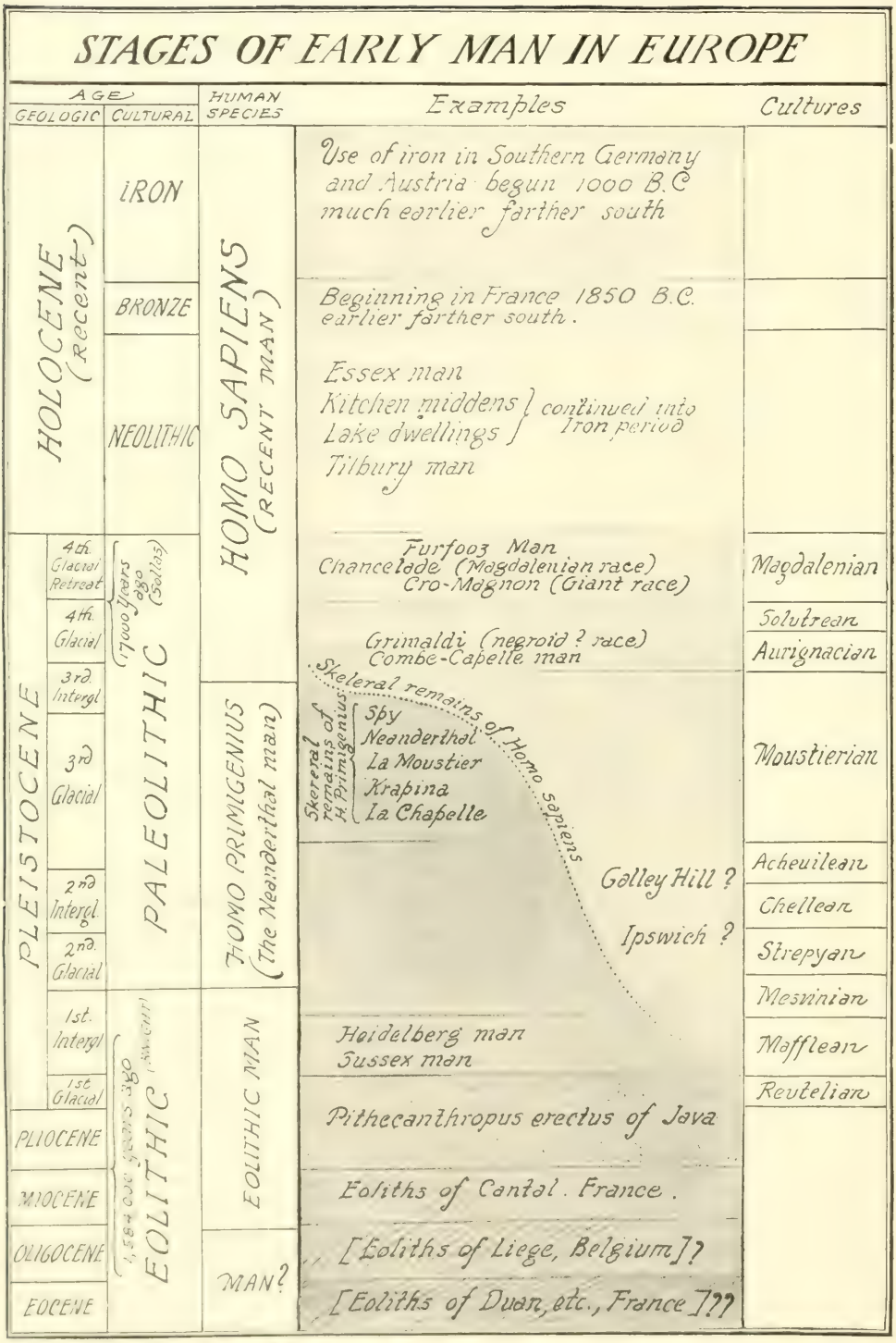
the molars and in the back molars being as large or larger than the anterior ones; from this rather close agreement they diverge into the permanent sets, in the anthropoids in the fang-like development of the canines especially, and in man in the degeneration of the back molars, the third or wisdom teeth being in the Aryan races small crowned and often wanting. The arm of the anthropoid is relatively longer than that of man; this is chiefly due to the great length of the forearm (radius and ulna) and occurs likewise in the human foetus and child. In the foot the great toe of the anthropoid stands at the same angle as the thumb on the hand and is smaller than the other toes; this is similarly true of the two-months old human foetus.

Thus in the case of the forehead, the teeth, etc., the young of the ape and man diverge strongly into the very different adult conditions.

Studies in evolution have shown that each individual animal and plant in its development from the egg or seed to maturity passes through successive stages and that these stages are similar to some of the adult stages of its successive ancestors from earliest geologic ages to the present. Illustrating this by but one example in man; we note that the lower jaw (Fig. 10) has at birth a strongly receding chin and a broad, short ascending branch with a shallow notch at top; at adolescence the chin is approximately vertical and the ascending branch is still short and broad with the notch at its top shallow; in the adult the chin projects forward, the ascending branch is long and narrow with its upper edge indented by a very deep notch; these three stages repeat almost exactly the types of jaw seen in Eolithic man, lower Paleolithic (Neanderthal), and recent man respectively. This suggests somewhat strongly that the Neanderthal and the Eolithic types of man are true ancestral stages of modern man.

Thus the most prominent features of man's physical evolution from the beginning of the Pleistocene to the present are seen to be the increase in prominence of the front cerebral portion of the brain case, producing a more and more upright forehead, the increase in the prominence of the chin and the parallel decrease in prominence of the upper jaw. Thus from a prognathous type, in which the retreating forehead and chin leave the tooth-bearing portion of the jaws projecting and prominent, has developed the modern orthognathous type in which the upper and lower parts of the face have come into

STAGES OF EARLY MAN IN EUROPE



This table gives a few of the principal finds of human remains, correlated with the geologic periods in which they occur, and with the type of implement with which they are associated. The widening space represents the increasing presence of Homo sapiens or the modern type of man. The narrowing space represents the decreasing presence of Homo primigenius or the Neanderthal type of man.

prominence and the jaws have retreated into line with them.*

The reader who may wish to follow up this subject will find the following books of interest.

"Ancient Types of Man,"—Arthur Keith, 1912, 151 pp.

"Prehistoric Man,"—W. L. H. Duckworth, 1912, 156 pp.

"Kultur der Urzeit," Vol. 1, on the Stone Age,—Professor Moritz Hoernes, 1912, 146 pp.

"Aus dem Werdegang der Menschheit. Der Urmensch vor und während der Eiszeit in Europa,"—Dr. H. von Buttel-Reepen, 1911, 139 pp.

"Paleolithic Man and Terramara Settlements in Europe,"—Robert Munro, 1912, 507 pp.

"Ancient Hunters,"—W. J. Sollas, 1911, 416 pp.

*The reason for such development is suggested by Robert Munro in his "Paleolithic Man." As the faculty of reasoning was more and more brought into play through the demands made on it for inventive skill in the fashioning of weapons and tools, human intelligence and hence brain substance steadily increased and the anterior portion of the skull had to grow to accommodate this increased cerebral substance; this increased weight of the anterior part of the head, if not counterbalanced, would have disturbed the poise of the head on the spinal column. Such counterbalance was partially effected by a concurrent retrocession or contraction of the lower part of the head, especially of the jawbones. As a result, the space allotted to the teeth diminished and thus the tooth-bearing portion of the jaws receded in prominence and as the teeth assumed a more upright position in their sockets the chin must concurrently come into greater prominence.

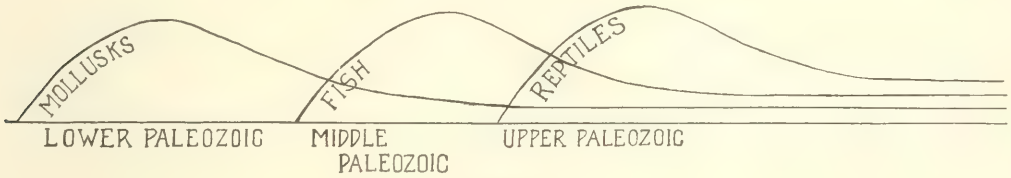


Fig. 12

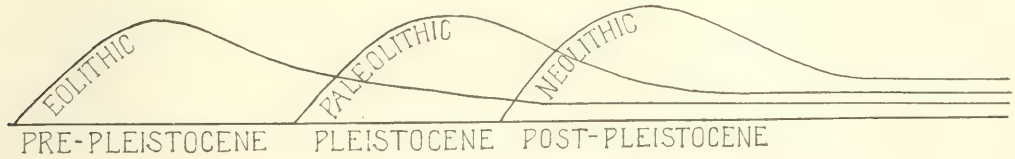


Fig. 13

Diagrams to illustrate that while in the course of geologic time more and more advanced types successfully appear yet some of the more primitive continue to exist side by side with the more advanced up to the present.

Figure 12 shows that though the mollusks, fish and reptiles arose at successive periods all continue to exist up to the present.

Figure 13 indicates the similar present persistence of the Eolithic, Paleolithic and Neolithic man and their probable similar successive appearance in the past.

CONCERNING THE CROP OF SCALLOPS

SCALLOP FARM A VARIABLE ASSET, BUT YIELDS QUICK RETURNS—COMMUNAL CULTIVATION AND TOWN COOPERATION UNDER STATE ADVICE ARE NECESSARY

BY JOHN RITCHIE, JR.

The scallop fishery is one of the four great shellfish industries which the shore inhabitants of Massachusetts have established, the others being the oyster, the quahaug and the clam. Its importance is such that in the interests of efficiency its limitations and its possibilities should be understood, and in the interests of conservation, since it affords more nutriment than any other one of the shellfish, and since sea food is likely to play a much more important part in this country in the future than in the past, the advantages of the industry should be discussed.

From the commercial point of view the scallop has both advantages and disadvantages. The crop is one that can be secured with little delay, when the generality of shellfish is considered. There is a large ratio of the edible portion to that which must be handled in the gross; the substance is palatable; it has high fuel value and in the fishery there is practically no risk of depleting the supply by over-fishing. On the other hand, on account of the restlessness of the animal it recommends itself rather for communal cultivation than for the business undertaking of the individual. There is an interesting story along most of these lines, and these stories are popularly but little known, yet they are of importance in properly understanding the problems which beset undertaking the improvement of scallop fishing as an industry. Oysters have been fished by modern methods for years, the sand clam is coming to its true place as a Massachusetts shore industry, and to keep pace with these the problems of the scallop should be considered with intelligence and with knowledge of the facts.

The Massachusetts Fish and Game Commission should receive the credit for an investigation of the industry as well as of the other shellfisheries, and in scientific ways and utilizing trained technical men it has taken up the consideration of the problems, discussing in a commonsense way the limitations of the industry, and besides establishing its status giving hints of ways and means of setting it upon a firmer basis. In the opinion of the commission the scallop fishery is not destined to become a great industry, but at the same time it is an important one in which the methods employed have grown up without particular thought or attention as to their efficiency. It is possible to employ most recent knowledge in the work, and in doing so to arrest the decline which the industry has suffered. It can be made valuable as an aid to the gaining of a livelihood by intelligent men, and it is not without its place when the food supply of the people is considered.

The most important particular in which the scallop differs from the other familiar food mollusks is the shortness of its life. The life seems to have, however, the usual complement of shortness, for the scallop is really a merry little beast. No one can doubt this who has seen the brilliancy of its bright eyes that almost twinkle, great, blue globules, one for every convolution of the shell margin, and each valve counts in this so that the eyes are in pairs, while its graceful dance as it bobs buoyantly along beneath the surface of the water has peculiar lightness and gives to it as a living creature an interest that its rival mollusks, the mud-loving clam and the bottom-seeking oyster can never hope to vie with from the popular standpoint.

The scallop is the perennial of the sea,

All the Illustrations by courtesy of Massachusetts Commissioners on Fisheries and Game.

and like the flowers to which this term is applied, the crop of next year depends directly upon the generation that is dominant today. The oysters that we eat are from the spat of some years ago, the sand clams may go on for a number of years reproducing their kind while the quahaugs have in their ranks many patriarchs who have seen the come and go of a number of years, but the scallop is an ephemeral. It has but one spawning season; it produces only the single litter of eggs, and only a small percentage of the whole species ever see a second birthday.

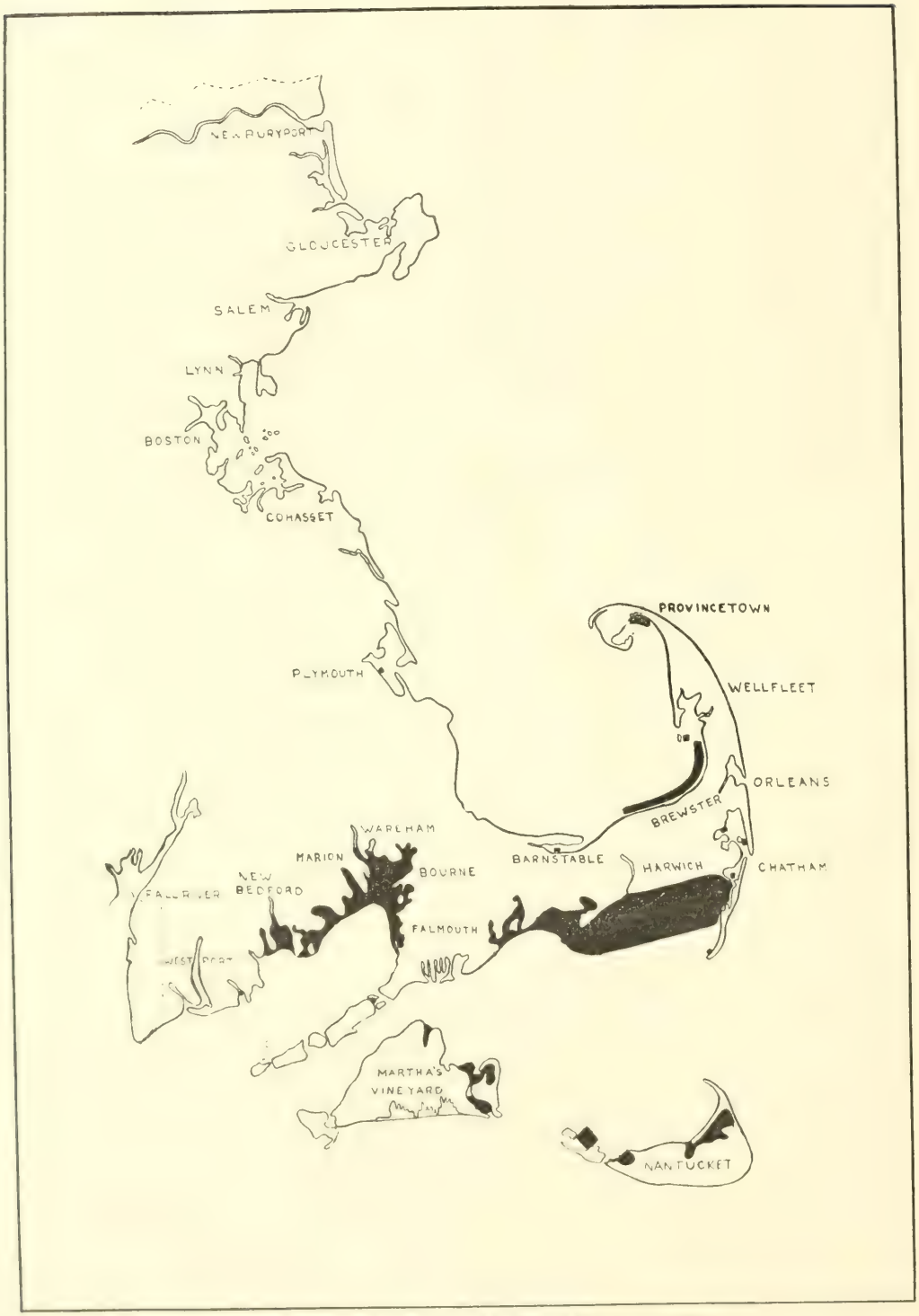
A number of important business matters hinge on this short life of the scallop. In the first place the fisherman has to wait only a year for his crop. The seed scallops of this summer will be ready for taking when the fishing begins next year, and the fisherman can take and should take every individual that comes to his dredge. He is not obliged to measure with a stick or a six-inch rule; he is not in fear of destroying his crop of next year, for if any doubt should arise he can determine whether the individual shellfish has passed its first birthday, and if it has he can take it without fear for it has laid its eggs and the next year's scallops are already growing. Just as the woodsman can tell the age of a tree by counting its rings so the scalloper can tell the age of his shellfish, only he seldom needs to count even two. For after one year, or rather the slow-growing months of the winter during which new shell accretes very slowly, there is a ring testifying to the arrested development. If the ring is there the scallop is adult, and if it is adult in October when it is taken it has contributed all that it can to the perpetuation of its race. It is rarely that the shellfish survives the second winter, so that, if not taken, it is likely to be wasted so far as the food of man is concerned.

The obverse of the shield is that, all the eggs being in one basket, if anything happens to that basket, the eggs will be lost. The whole race of scallops may be exterminated in any locality by widespread unsuitable conditions. These conditions are natural, the cold of winter, severe storms or anchor ice that drags away the scallops or the eel-grass to which they are moored. The individual scallop farmer may find his whole colony of shellfish destroyed in a season and he has no means at hand whereby to prevent this. Such facts militate against attempted cultivation in definite, separate farms, and it is this for one thing that has caused the Fish and Game Commission to suggest communal farming of scallops.

Then again the scallops are mildly migratory. The extent to which they do actually change their abodes has been magnified by that hyperbole inseparable from things marine, and they have been described as swimming away in orderly troops, seeking other shores and masters. The Massachusetts investigations have been the means of extracting the grain of truth from the mass of exaggeration.

The scallop is a free swimmer. It can maintain itself, valve-margin uppermost, in the place that suits itself with reference to the surface of the water, doing this by jets of liquid expelled by vigorously closing its valves. It has a levitation that suggests the balloon in air. In a position not vertical the impulse jumps the bivalve through the water in the direction towards which it leans. It has been determined, however, that the radius of voluntary swimming is limited, so that swimming may be regarded as a minor factor in the distribution of these creatures. Buoyancy and wave motion together, be the latter tide or storm, may clear a little sea-farm of its scallops in a single day. And the farmer can hardly depend upon any reverse of tide to bring his bivalves home.

It is such facts as these that suggest to students of the problems, such men as David L. Belding, who is the biologist of the Massachusetts Commission, that compared with the three other shellfishes, the oyster, quahaug and clam, the scallop is susceptible of much less of what may be termed cultivation. At the same time it is an industry that means part-time and part-livelihood for between six and seven hundred men, and might mean much more. Further there is employed part of a capital of $125,000, for which the annual return is about equal to the whole



Scalloping Grounds are indicated by Black Patches and Dots

Seed Scallops, which have not yet spawned. The perpetuation of the scallops in the vicinity depends upon these and they must not be taken. They are protected by law.

capital. These figures are merely approximate since the fishery is not an independent one. Many of the same men and boats are at work part-time taking quahaugs and many of the scallops are taken on quahaug beds, so there is difficulty under the circumstances in getting precise figures.

The place of the scallop industry may perhaps be best illustrated by bringing forward the figures, so far as they have been determined. The quahaugs yield in Massachusetts about $200,000 a year, the oysters about $175,000, the clams about $150,000 and the scallops, $165,000. To get these returns there are 160 oystermen with an investment of $1,600 for each man employed; in the taking of quahaugs there are 750 men with a capital of $130 for each; the scallops give employment for a time to 650 men and the capital needed is about $150 per man, while for the clam there are double as many men employed but the capital here required is little more than the clamfork and baskets, and reaches only about ten or twelve dollars a man. One can gain from this some idea of the complication of the financial end, the relations of capital and labor, and how this varies for the different industries.

There is a further complication in the seasons during which the different industries are worked and their relations to other pursuits of the fishermen. The men engaged in one fishery may shift to another if the open seasons do not overlap. The beginning of the scallop season marks the decline of the quahaugging. In fact some legislation with reference to the former has been made in consequence of the chance to fish the latter. The quahaug is a summer shellfish while the scallop is spawning in warm weather and may be taken from October till April. The quahaug men have also a summer lull partly because the same men are required for the lucrative work induced by the summer visitor. The oysters have a winter catch, beginning in September

Adult scallops. At the edge of the dark area is the annual growth line. Absence of this line defines the molusk to be a seed scallop. These adults have spawned and few ever reach the second birthday. They can all be taken for food.

and lasting as long as the weather will permit.

When all the facts are considered they seem to justify the conclusion of the Fish and Game Commission that the scalloping industry is not likely to become a dominant one, for the scallop has the two weak links in its chain, its perennial nature and the fact that individual scallop farms are a variable asset. It is true, however, that the discovery of a method of artificial propagation of the scallop, which if successful would do away with the enormous "infant mortality" of the shellfish, might go far towards eliminating the weak places, but till today such methods are lacking.

An adult scallop—the name of the species, by the way, being Pecten irradians, which gives way under rules of priority now to P. gibbus, var borealis—when it is two and one-half inches in diameter, will produce in its spawning season about four to five million eggs and a Pecten, an inch smaller, only one-third as many. At the same time the scallop liberates into the water from twenty-five to fifty billion spermatozoa, whose duty it is to fertilize the eggs. In the wastefulness of Nature, however, only a few eggs develop to mature scallops, perhaps ten to a litter.

This number, small as it is, is sufficient to maintain the race, but if, as with the lobster, a method could be devised or evolved whereby to save a larger ratio of the eggs, problems like that of re-stocking might be solved.

The development of the egg after it is fertilized has been shown by experiments by Mr. Belding to be a matter of minutes. The usual order of cleavages is observed and to the number of sixteen cells requires only about one hundred minutes. In nine to twelve hours the little scallop has developed ciliæ and can swim by

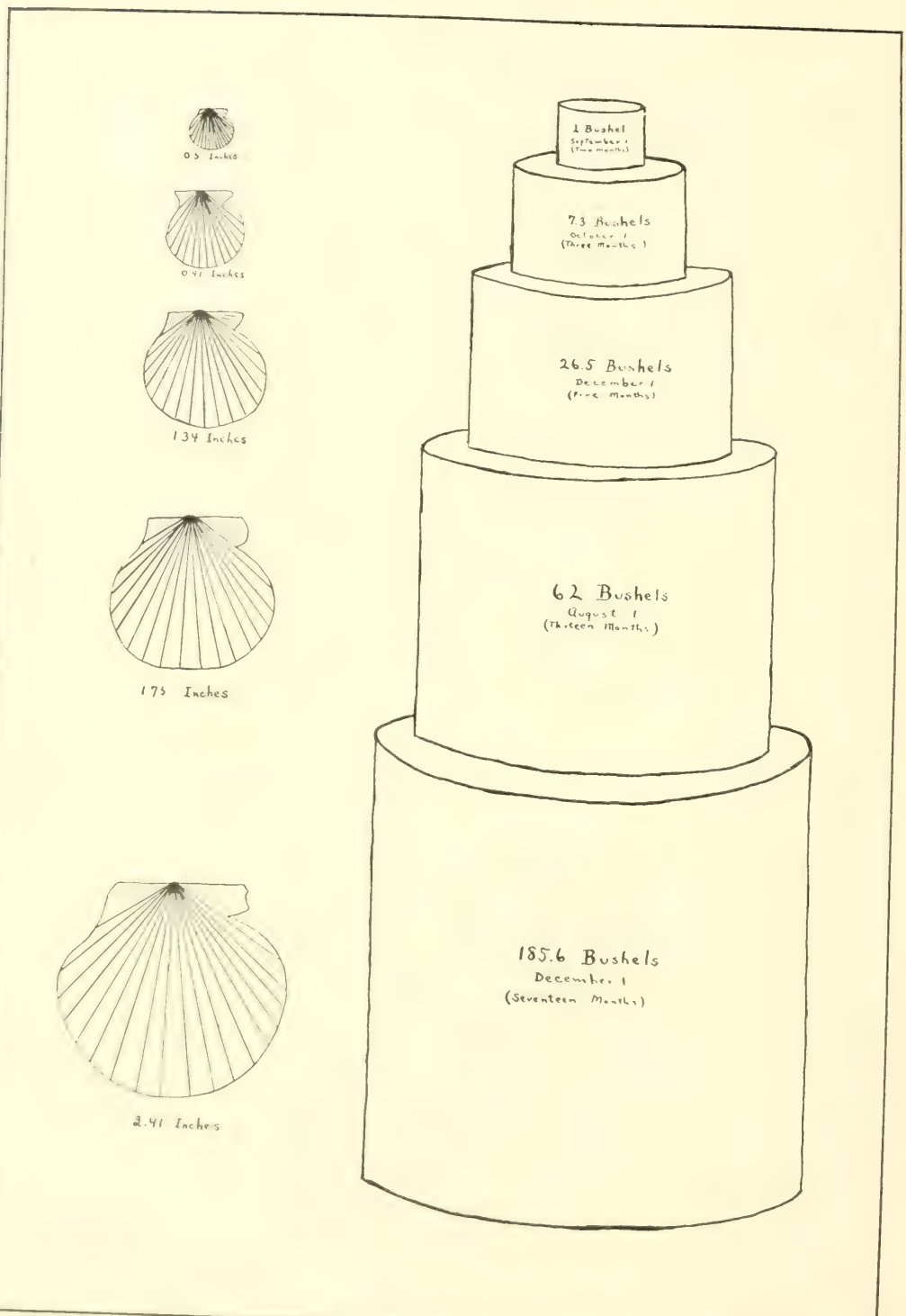
Dredging Scallops off Nantucket.

means of them. It is still a mass of cells of which the outer ones have developed the hair-like appendages and acquired the ability to wave them. The vast majority of eggs never reach this stage. In about half-a-day the shell gland is formed and in a few hours more there has grown over the body of the little swimmer the thin, transparent shell which later develops into the corrugated form characteristic of the scallop. After a while the little creature, here in what is termed the veliger stage, swims by means of a minute paddle and later the foot, which is a distinctive feature in all mollusks, takes its place. Then there is the further growth and development into the form so familiar to those who know the scallop.

Like many others of the shellfish this one has the ability of settling down in some desired place and here it homes itself by the marine mode of mooring. The cable is merely a few fine gossamer threads, although some of its neighbors not far removed in the classification of the mollusca depend largely upon such attachment and spin many threads which have the collective name of the byssus and the popular one of the beard. Such permanent cables have oftentimes a special notch in the valves through which it extends and some even a well-formed, regular hawse-hole.

The byssus of the young Pecten is formed a thread at a time and the number is dependent upon circumstances, more being necessary where there is a current. The older scallops, however, may return to their earlier freedom of youth, and in storm or stress may be at the mercy of the waves. Thus it is that they are not infrequently cast in windrows upon the beach, whence quick removal is necessary if they are to be saved at all.

This is the factor whereby the adult scallop may be forced to change its place



Growth of the Scallop. The shell figures indicate the increase in size of the scallop and the cylinders the gain in volume, in the times indicated, two, three, five, thirteen and seventeen months.

from the farm of one man to that of another, or be swept to sea or upon the beach, and in a sense makes of the scallop industry a real fishery with its proportion of luck. It has been established pretty certainly, however, by the Fish and Game Commission that the limits of a harbor may very well mark the extent of this movement, so that while the individual is handicapped, the community which may have rights in an extent of shore or harbor line will not be sensibly disturbed, no matter at which particular point on the shore the scallops may be found.

A few little bays have been noted along the shore, inlets with narrow mouths, which afford reasonable safety for the individual culture of the crop but these are the exception to the general rule, and it is true that scallops are particularly suited for a communal industry. Such cultivation is not considered in present legislation which is directed towards regulating the individual, specifying in general the closed season, the quantity to be taken and giving attention to the protection of seed scallops. The importance of communal culture is further shown in the possibility which would then exist of restocking barren areas, which under present protection of the seed and the lack of cooperation between towns and individuals is not practicable. Here is suggested the need for State supervision or mediation, since it is true that local rivalries have in the past prevented the restocking of a deserted area from wasteful plenty just across a town boundary.

That there are possibilities in the scallop culture even beyond the conservative estimate of the authorities seems likely when one considers all the conditions. There are about thirty-one thousand acres—nearly fifty square miles—of shore and sea farm suitable for their growth. That which is in good bearing condition today lies mostly south of the elbow of Cape Cod. The shores of Buzzard's Bay and Vineyard Sound, Martha's Vineyard and Nantucket here included, are the best places, with a small distribution at Provincetown, some fisheries along the inner arm of the Cape at Brewster with scattered places where they have been found as far as Plymouth. None are known north of Boston.

It is thus a partial industry affecting only a limited portion of the shore line, and by no means all of this, for on account of the combinations of the circumstances and handicaps mentioned, only a small part of this is in bearing at one time. Future study ought to make more wide the culture and future legislation more easy the sensible regulation of it.

The fishery of scallops under present customs is very wasteful. The only portion that is eaten by man is the great muscle which serves to close the shells and hold them together. This is only about one-third of the meat of the creature and one-fifth of the gross weight including shell. Even at this the scallop has great advantage over the oyster and the quahaug and some over the ordinary clam, although the paper shells that result from quick growth under modern conditions of clam cultivation can reduce this. The other portions of the scallop are used for bait, but there seems to be no good reason save custom, for using so little for human food. It may be that some new culinary development may find here an increase of available food material and make greater and more reliable the demand for it in the market.

THE USES OF OZONE

The uses of ozone for various purposes which add to the comfort of man have recently been widened because of its commercial exploitation. It is used for deodorizing, purifying drinking water, for sterilizing in hospitals, as an adjunct to cold storage preservation, for sterilizing casks and vaults in breweries, in the aging of beer, in improving the air in homes, offices, and public buildings, as an aid in therapeutics and as a bleaching agent. The gas, however, is extremely unstable, and heat and moisture are both unfavorable to its preservation. New processes are being perfected, however, so that the unfavorable conditions heretofore presented are being minimized, and the uses of ozone multiplied.

EHRLICH'S CHEMOTHERAPY

HOW HIS LOGICAL, SYSTEMATIC CAMPAIGN AGAINST CERTAIN DISEASES HAS DEMONSTRATED THE VALUE OF SCIENTIFIC METHODS IN THERAPEUTICAL PROBLEMS

BY HENRY P. TALBOT

Chemotherapy has been called "a new science." It should, rather, be regarded as the designation of a scientific field in which therapeutics and chemistry intermingle in the solution of problems involving the principles of both of the older sciences, much as do physics and chemistry in so-called "physical chemistry," which is not, on that account, regarded as a "new" science.

Therapeutics is defined as that branch of medical science "which deals with the composition, application, and modes of operation of the remedies for disease." But it has now taken on a somewhat broader, though less exact, meaning, and is understood to include the general administration of medicine, questions of hygiene and dietetics, and much that has to do mainly with the general well-being of the individual. That chemistry must be, as it has been for centuries, inseparable from the study of therapeutics is obvious, and the advance from the simplicity of the theory of Geber, according to which the animal organism was made up of only "sulphur" and "mercury" to our still very imperfect knowledge of the complex changes of physiological processes is, indeed, remarkable. But modern medical and chemical science is not content with the mere alleviation of the ravages of existing disease, that is, with the modifying or assisting of functions temporarily disturbed, but has struck more directly at the root of the trouble by devising means actually to destroy the causative agents and thus arrest the disease, or to render the animal organism inhospitable to these causative agents, as, for example, through the anti-toxins and the methods of preventive medicine in general.

All this had been done even before the advent of chemotherapy. What, then, is new about this combination of scientific effort in two allied fields? Essentially this: It is a logical, systematic campaign against diseases which are caused by the infection of the animal organism by parasites (i. e., bacteria or protozoa) by means of chemicals which have not been found by empirical and more or less haphazard methods, but have been synthesized and built up solely for the purpose in hand, and as the result of researches which have called for the highest type of accurate observation and analytical reasoning for their execution. In this way it has been found possible to devise means by which the animal organism can be sterilized with respect to the parasites in question, and the consequent symptoms of disease can be arrested.

The development of this field is due almost entirely to Professor Paul Ehrlich, of Frankfort, and his co-workers. Dr. Ehrlich was educated as a physician, but has now become also one of the most accomplished and able investigators in the field of synthetic organic chemistry. A conception of the significance of his work can, perhaps, be best obtained by noting important phases in its progressive development.

More than thirty years ago Ehrlich began using coal-tar colors in his physiological studies, employing them as stains for preparations to be examined under the microscope. It is, of course, now commonly known that certain dye-stuffs appear to have a selective affinity for certain tissues of the body, or for certain parasites when residing within it, and these stains are in every day use by the pathologist. But it was not so thirty

years ago, and Ehrlich first found that a dye-stuff known as methylene-blue, and its congeners, were the only colors which would stain live nerve tissue, and drew from this the important inference, which is at the basis of chemotherapy, that this was because of a particular receptivity for these dye-stuffs on the part of these tissues or parasites. It is easy to understand something of the importance of this use of these stains, or dyes, if it is recalled that the changes produced in the individual cells or tissues by drugs are not detectable even under the microscope in most cases, and that it is only through these stains that a knowledge of what has actually happened can be even approximately learned.

Ehrlich concluded from his observations that it was probable that, since these tissues and parasites possessed this receptivity for these specific bodies, there must be some definite effect produced as a result of the combination, if combination it were, and proceeded to conduct investigations in this direction. After some time these researches were rewarded, and in 1890 Ehrlich and Lappmann published a paper on the pain-relieving properties of methylene-blue, and, later, Ehrlich and Guttmann found that the same dye was fatal to one type of the plasmodium, the parasite which causes malaria. As the latter field of investigation, that of the effect upon parasites, appeared very promising, they turned their attention to a particular class of parasites known as trypanosomes, because these could be more easily studied by the inoculation of mice.

The disease-producing parasites are sometimes of vegetable origin, as the bacteria, and sometimes of animal nature, as the protozoa. The trypanosomes are worm-like bodies, somewhat larger than bacteria, belonging to the animal class, and the diseases which they produce prevail most generally in tropical countries. Of these diseases, surra, most generally known in India among cattle, dogs and camels; nagana (tsetse-fly disease), known in Africa among animals in general; and mal de cadaras, known in South America among horses, are typical, while manisalso attacked by the sleeping sickness in the tropics. The scourge of syphilis is produced by a parasite known as the spirochete, which is closely allied to the others named, although it is still undetermined whether its nature is animal or vegetable. As will be seen, this particular disease has been found to be one of the most amenable to treatment.

As a result of his researches, Ehrlich formulated a theory regarding the behavior of the cells of living tissue, or of parasites toward foreign bodies. He conceives them as made up of a central "dominant body," which throws out "side-chains," to which he later gave the name receptors. These are of variable character, some being nutrient receptors, and others chemo-receptors, that is, receptors or certain definite chemical elements or groups of elements, known in chemistry as radicals. In a crude sense, the receptors may be likened to locks, and the nutrient or chemical bodies as keys, each fitting a particular lock, as, for example, the dye-stuff methylene-blue, already mentioned. The combinations thus effected may be beneficial to the cell, as in the case of the nutrients, or they may result in the poisoning and death of the cell, as in the case of the methylene-blue when brought into contact with the type of plasmodium referred to above, or quinine for plasmodia in general, a specific remedy for malaria discovered by empirical research.

Ehrlich and his co-workers, with extraordinary skill and industry, prepared several hundred dye-stuffs, studying the varying effects of alterations in chemical structure, each new compound having been logically selected as the result of laboratory tests of its parasiticidal efficiency. Of all these, very few finally withstood severe tests, possibly not more than ten in all, but the fact was established that it was possible in certain cases to sterilize the animal organism with respect to parasites, by this means, without, at the same time, poisoning the animal itself. They were also able to establish certain principles as to the chemical structure of the dye-stuffs most likely to

be effective. They encountered, however, many difficulties. A dye which would attack and destroy a given parasite in a particular animal would not always do so in another species. Symptoms of disease would sometimes recur after varying intervals, and the parasites would then often exhibit peculiar resistance to further attack.

While these researches were still in progress, Uhlenmuth and Salmon published an account of instances of marked success in the destruction of the spirochete of syphilis, and the arrest of the disease, by the use of an arsenical compound known as atoxyl. Secondary and seriously harmful effects to the patients were, however, the consequence of this treatment, but the parasiticidal properties of this compound were so marked that Ehrlich turned his attention to it, in an attempt to so modify its effects upon the animal organism which was harboring the parasites, that its curative power might be made available.

The task was by no means a simple one. He first established the composition of the atoxyl as a para-amido-phenyl arsenic acid. The vast amount of work already done with the dye-stuffs indicated certain lines of probable success, which, nevertheless, was only attained on the synthesis of the six hundred and sixth organic compound by Ehrlich and Kata, sometimes known as "606," and now designated salvarsan. Chemically it is a dioxy-diamido-arseno-benzol, in which arsenic is associated with structural groups akin to those found in the dye-stuffs. A later preparation "914," known as neo-salvarsan, is said to be a combination of salvarsan with sodium formaldehyde sulphoxalate, which is designed to overcome a certain difficulty in administration of the salvarsan, due to acidity of its solutions.

Ehrlich assumes that the parasite of syphilis, the spirochete, possesses among others, arseno-receptors, and that through the combination with this arsenic compound the parasite is poisoned and dies. Ehrlich claims that in more than twelve thousand cases in which this drug has been administered by him, no single case of poisoning has resulted. The administration of the drug, which is intravenous, or intramuscular, requires, however, considerable skill and care. The treatment with salvarsan is often combined with that of mercury. There seems to be no doubt that this preparation exerts a specific and destructive action upon the spirochete, and has already resulted in the alleviation of an enormous amount of suffering (often hereditary and undeserved) from this dreadful scourge. It is still too early to make final statements as to the permanence of the cures effected although there is much reason for hopefulness. It should, however, be noted that this chemotherapeutic treatment, unlike the anti-toxin treatment for certain other diseases, does not at all produce immunity from later infection from the same disease. Indeed, there is some evidence to show that cases of re-infection are distinctly harder to treat successfully than those of initial infection. The cure of advanced cases of the disease naturally, presents greater difficulties, because of secondary disturbances of the vital organs, but many of these have been materially alleviated.

The progress made in the chemotherapeutic treatment of diseases produced by other trypanosomes, notably that of the "sleeping sickness," has been less marked up to the present. Something has been gained, but no specific drug comparable with salvarsan in its efficiency has yet been found.

It is, however, recorded that in Surinam a hospital was established to treat cases of another tropical disease known as the yaws. In the course of eight days three hundred and twenty-eight cases were admitted, and at the end of fourteen days the last patient was discharged, cured, and the hospital had to be closed.

In another field the work of Ehrlich has led to procedures which are of the greatest promise in the study of the processes involved in the progress of medical and physiological research, namely, so-called "vital staining." By means of the

injection of dye-stuffs into living organisms, it is possible, because of the selective receptivity of certain tissues or parasites, for a particular color, to trace the movement of bacilli, and to watch the changes which they occasion in the living organism itself. The same procedure is employed in the study of healthy tissue.

To Ehrlich's clear, analytical mind, exceptional executive ability, fine technique, and extraordinary industry is due not only the procedure by which certain particular diseases may be arrested, but a splendid example of logical attack upon other similar problems, which offers great promise for the future, even though, as in the case of the anti-toxins, one marked success may not be at once followed by others of equal moment. He has demonstrated, in a way which cannot be detailed in the scope of this article, that the test-tube experiments made in the laboratory with a particular drug upon a special parasite cannot be alone relied upon as an index of the effect upon it of the same drug when it is harbored by the living organism, since the action is essentially modified by that organism, and he has advanced theories which at least help in the understanding of the possible reasons for the variations in behavior thus observed. Even though Ehrlich's chemotherapy may not be, in an exact sense, a "new science," it must be acknowledged to be a most fruitful and helpful combination of the principles of two well-recognized and time-honored sciences for the benefit of mankind.

LIQUID AIR AS AN EXPLOSIVE

When liquid air is suddenly heated, for example by an electric spark, it will explode. Early attempts to utilize this property for blasting purposes were rendered futile because of the difficulty of getting the liquid air in place and igniting it before it had completely evaporated. A German has succeeded in overcoming this difficulty by first placing the cartridge in position, performing the necessary operations of tamping, and lastly introducing the liquid air into the cartridge through a small tube.

The liquid air can be prepared by a cheap process at the place of consumption, in fact in the mine itself. This does away with the possibility of the lamentable accidents that so often attend the transportation and storage of dynamite. Liquid air has the additional advantages that it cannot be stolen for unlawful purposes and that the gas formed by the explosion, air, is beneficial rather than detrimental to the miners. E. B. S.

DETECTION BY ULTRA-VIOLET RAYS

It has been the custom of successful check raisers to use chemicals for removing the written matter upon a check and then filling out the body in close imitation of the original. The most successful criminals of this type are able to effect this alteration in a check in such a manner as to make no change in the texture of the paper and leave no trace of their work. Professor Woods of the Johns Hopkins University has found that by photographing a check suspected of being raised, by means of ultra-violet rays, the erasure can be detected. In cases where even a high power magnifying glass was unable to show any tampering with a raised check, Professor Woods has photographed it using ultra-violet rays, the print clearly showing a smudge where the erasure had been made. This new method of detection differs from the chemical processes heretofore used in that no chemical change is made in the document itself.

AMMONIA AS A DISINFECTANT

It has recently been discovered that ordinary ammonia is a powerful disinfectant even for virulent diseases. The bacilli of cholera and typhoid were killed in two hours by allowing an aqueous solution of ammonia to evaporate in a closed space. The bacteria and spores of anthrax yielded to the same treatment in three hours and diphtheria in eight. The method is simple, cheap and not at all injurious to the furnishings of the room. Linen may, of course, be disinfected by washing in this liquid.

E. B. S.

A FALLING CHIMNEY

A PHOTOGRAPHER of the *Newark Evening News* was fortunate in securing the picture of a falling chimney as it was being razed, reproduction of which appears on this page. The procedure in demolishing the chimney was to take down part of the masonry just above the base, inserting wooden wedges and timbers into the slot and then burning out the underpinning, so weakening it that the chimney would tip over.

It is interesting to note the similarity of the fractures on this chimney and the lesions produced on the chimney in another picture on this page, which was left standing after the earthquake at Messina in 1910. These lesions indicated clearly the direction of the earth wave. The last picture is taken from SCIENCE CONSPECTUS, February, 1911.

The Italian Navy has recently equipped a new towboat with Diesel oil engines of the four-cylinder, two cycle type.

THE SOCIETY OF ARTS OF THE MASSACHUSETTS INSTITUTE OF TECHNOLOGY

The Society of Arts was established as a department of the Institute by President Rogers in 1861. It is especially devoted to the general dissemination of scientific knowledge, and it aims to awaken and maintain an interest in the recent advances and practical application of the sciences.

Any person interested in the aims of the Society is eligible to membership.

The annual dues are $3.

RICHARD C. MACLAURIN, President of the Institute.
ISAAC W. LITCHFIELD, Secretary of the Society of Arts.

EXECUTIVE COMMITTEE

THE PRESIDENT
ELIHU THOMSON
JAMES P. MUNROE
THEODORE N. VAIL
ARTHUR D. LITTLE
FREDERIC H. FAY

THE SECRETARY

BOARD OF PUBLICATION

D. F. COMSTOCK
SELSKAR M. GUNN
ELLWOOD B. SPEAR
LEWIS E. MOORE

I. W. LITCHFIELD, Editor

SCIENCE CONSPECTUS is published December, January, February, March and April.

DOCTORS OF CIVILIZATION

READ the terse yet masterful account that Thucydides gives of the "Black Death," a scourge which, despite their remarkable civilization, the ancient peoples clustered in southeastern Europe and Asia Minor were unable to combat, or peruse Pepys' description of the terrible ravages of the Great Plague in London, and the thought strikes home that the gregarious instinct of man cannot be satisfied without paying a tragic toll. The diseases of perilous occupations, the accidents due to unprotected machinery, the ills obviously caused by poor ventilation, all these can be avoided by the ingenuity of the architect and the engineer. But the pests that have decimated even a rural population are not prevented in any obvious way. Their origin is hidden in wells that apparently yield only pure water, in the bites of insects apparently harmless. They are, in truth, diseases of civilization, which require for their eradication scientific investigation as painstaking and self-sacrificing as the researches that have given us the wonderful antitoxins and sera by which we cure typhoid fever, diphtheria, pneumonia and other maladies, formerly considered fatal.

Not until the bacteriologist with his microscope and his stains had discovered the germs, invisible to the naked eye, that are responsible for most of the ills which flesh is heir to, did it become possible to create the modern profession of sanitary engineering—to educate, in a word, the doctor of civilization. Prevention is the watchword of that new profession—prevention of the conditions under which deadly bacteria may thrive and prevention of the transmission of these bacteria should they breed. Not without the sacrifice of men who could ill be spared has this truth been learned. Heroes have been found, willing to subject themselves to the stings of bacteria-carrying insects, in order to prove that not the exhalations of swamps but the natural inoculating needle of the mosquito is the real cause of some infectious diseases; that miasmas do not in themselves cause ills, but simply aid the breeding of the living vehicles that carry disease germs.

Within the lifetime of living men it was thought that only a physician was fitted to be head of a Board of Health. Even in the smaller towns a medical man is still found intrusted with the well-being of hundreds and perhaps thousands of town dwellers. Gradually, the new doctor of civilization, the sanitary engineer, with the ills of individual human beings the public health expert trained to cope not but with epidemics that devastate whole

communities, is coming to the front. Such is the need for these men that our technical institutions are now offering courses in sanitary engineering. To the Massachusetts Institute of Technology belongs the credit of having, years ago, established the first of these under the guidance of Prof. W. T. Sedgwick. Other institutions soon followed. They have all justified their existence by graduating many students, now actively and successfully engaged in public health work. Not many years will pass when the health of every community will be intrusted not to a graduate physician but to a trained public health expert.—*Scientific American.*

SURFACE COMBUSTION

It has been noted that if a mixture of gas and air emitted at high velocity, as from a Bunsen burner, is directed against a red-hot fire brick held a short distance away, the mixture will burn at the surface of the brick. This phenomenon is known as "surface combustion." A useful example of this application is the heating of crucibles placed in a furnace and packed in a highly refractory granular material. The explosive mixture is forced into this granular material through an opening in the lower part of the furnace below the crucible and when properly adjusted, combustion will go on quietly, without a flame, within the granular material surrounding the crucible, producing a state of intense incandescence. The advantages claimed for this system are that the combustion is greatly accelerated by the incandescent surface and can be directed upon the object where the heat is required. The combustion is perfect with a minimum excess of air, and the attainment of very high temperatures is possible.

One valuable application of the process is known as diaphragm heating. The diaphragm is made of a granular refractory material held together by a suitable binder which is of porous structure so that the combustible gaseous mixture can flow through it. When the gas is turned on and ignited above the surface of the diaphragm it will first burn with a flame but as soon as the diaphragm becomes heated the flame will disappear, combustion taking place at the surface of the pores of the diaphragm. The temperature is regulated by adjusting the amount of gaseous mixture supplied. By this means temperatures can be produced far above the melting point of platinum. A muffle heated to a certain temperature by ordinary means was found to require 105 cubic feet of gas per hour, while the same muffle heated to the same temperature by surface combustion required only 43 cubic feet of gas per hour. The most important application of surface combustion is in heating steam boilers which has recently been successfully tried although the underlying idea involved is not new.

CORROSION ACCELERATED BY PAINT

With reference to the protection given to iron by paints, two prominent German chemists report that the corrosion of the iron plate was increased by certain of the commoner paints. In one of the tests brightly polished iron plates were covered with the following paints; white lead, zinc white, red lead, iron oxide, white lead and lampblack, zinc white and lampblack. These plates were then subjected to the action of steam from water boiling in an open furnace, for a whole day and the paint was then dissolved. Strange to say, under the single coats the iron was not at all rusted, but under the double coatings there were plain indications of attack by rust, the rusting being increased as the number of coatings were multiplied.

A HIGHWAY EXHIBIT

During the next year the State of Washington will spend $8,000,000 on road construction. At Olympia, Washington, various paving companies are laying samples of roadway 16 ft. wide and 100 ft. long in accordance with their own specifications which are filed with the State Highway Department. This stretch of throughfare forms a part of the north and south highway throughout the state.

SCIENCE CONSPECTUS

VOL. III APRIL, 1913 NO. 5

DOOM OF THE LOBSTER

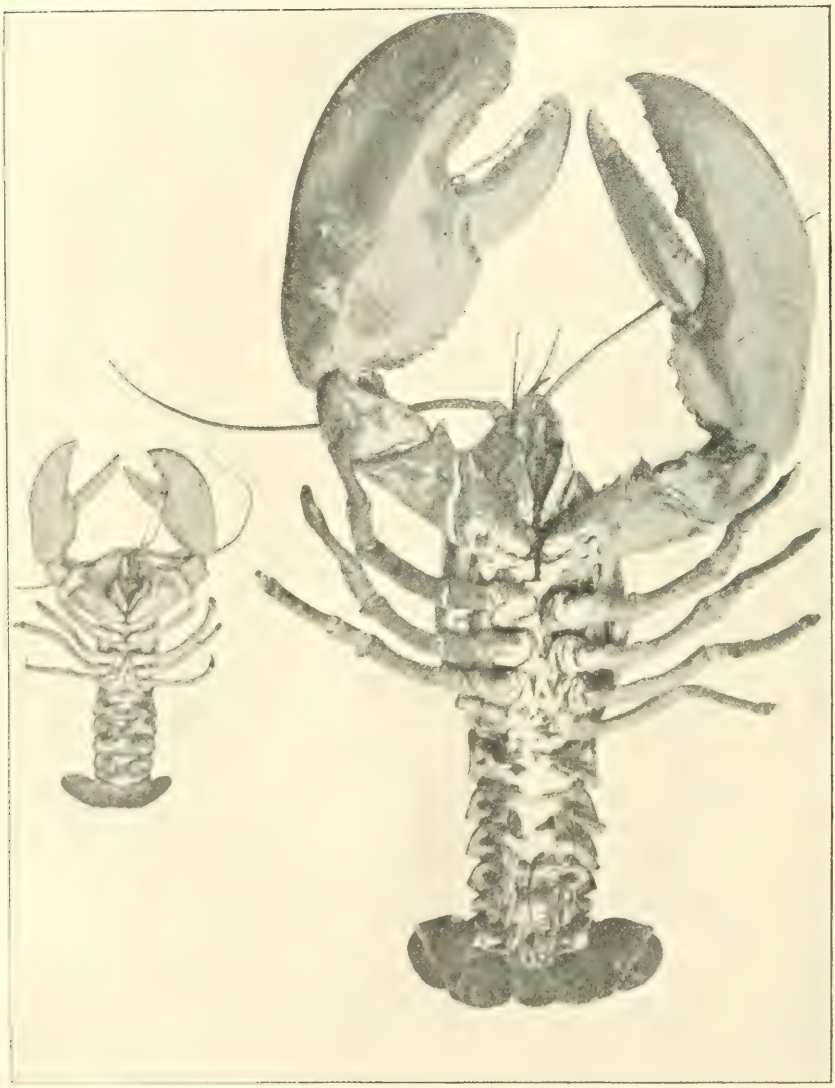
PRESENT FISHING METHODS MEAN COMMERCIAL EXTINCTION. REMEDY IS SIMPLE AND PRACTICAL BUT NEEDS INTERSTATE AND INTERNATIONAL UNITY OF ACTION

BY JOHN RITCHIE, JR.

THE twentieth century methods of fishing for lobsters present a direct violation of fundamental principles of conservation, being a chapter in the utter lack of effort on the part of man to take any heed of the future. The ruthless destruction of large game and the extermination in this country of the buffalo are other phases of the wastefulness of man, but these affect but little his real comfort and his sustenance. The commercialism that injures closely settled places, as does the "robbing" of coal pillars at Scranton, is a grievous waste of money that the public must bear in the end, but this inconveniences rather than injures, provided of course the city land owners can get without too much legal delay or monetary loss the value of their sunken estates. The lumber operator works great hardship from the point of view of conservation, but his ravages and waste and even those caused by the conflagrations which follow in his wake will almost always be repaired by Nature. But the lobster can see for himself no other ultimate—and ultimate here means also proximate—fate but to be practically exterminated, for the simple reason that those now in the industry seek to gain from it the utmost that it will afford, without a care for the morrow, while legislators take their cue from those who are seeking the gain. States hold their hands for they fear the competition of other states that are less restricted, while governments keep aloof from what might be infringement of states' rights. And all the while the destruction continues.

Lobster fishery today has for its motive commercialism of the kind that may be expressed by "for what is in it." There is only very locally any excitement of the chase which has been the excuse for the extermination of the larger mammals. It does not present the economic question of gaining what can be gained in what seems at best an insufficient supply, as in the Pennsylvania coal, while there is afforded no real opportunity for natural restocking as in forestry. Wherever man has fished the sea for lobsters, and that is everywhere that they have abounded, the supply has been depleted.

There is no one in authority who does not know of the enormous decrease in the lobster supply and that commercial extinction is the fate of the crustacean unless matters can very quickly be mended, and at the same time no individual in authority has the means by himself to solve the problem. Matters of this character cannot be righted till the people understand the situation. There was short shrift for the real food adulterator when the people learned of actual food conditions; there has been rapid improvement in water supplies



Relative Sizes, the smaller one weighing 1½ lbs., the larger one, 23 lbs.

since the people have learned to connect with impure ones the dread name, "typhoid," and the public now educated is demanding the proper protection of the healthy from the dangers spread about by tuberculates. An education of this kind must underlie the establishment of principles for the sane fishery of the lobster, before progress toward that object can be assured. There is even at this late day no reason why the lobster cannot be maintained as a regular, constant element and one of great importance, in the food supply. But this means that the principles known to the scientists must be recognized by the people, so that with their support the authorities can act along those lines which they already realize are the only ones bearing hope. What should be done has already been formulated, and the first statement of the principles is to the credit of Massachusetts, whose chairman of the Commissioners on Fisheries and Game, Dr. George W. Field, first showed that present methods are wrong and must be reversed.

Dr. Field is a Massachusetts man whose training fits him for the consideration of just such problems as this. Graduated at Brown, with a Ph.D. from Johns Hopkins, he has been the investigator at the Smithsonian table at Naples, a member of the instructing staff in biology at Brown, Johns Hopkins and the Massachusetts Institute of Technology, from which latter college he went to the Massachusetts commission for a year as biologist, and since 1904 has been its chairman. He is the first man in this or any other country to look properly at the lobster question. His utterances and published statements of a dozen years ago stand today high in the estimation of up-to-date heads of fishery departments. The other methods have been tried out and not with success. His suggestions are philosophical and scientific, and are worthy of a better understanding by the public.

"If we would preserve this fishery," writes Professor Francis H. Herrick in his classic, "Natural History of the American Lobster," "we must reverse our laws as Dr. Field has ably pointed out, and follow the principles and practices of breeders of domestic animals everywhere—use the smaller and better animals for food, and keep the older, and in this case, by far the most valuable, for propagation." And there is the matter in a nutshell, protection for the fruitful, egg-producing, adult lobster.

The knowledge of scarcity of lobsters is not new. Sweden as early as 1686 enacted restrictive legislation as to lobster fishing, and in this State just one hundred years ago Provincetown required permits, the direct motive here urged being fear of exterminating the animal. There was next a minimum length limit established in 1874 about which time a wave of insecurity penetrated to various lobster consuming countries. In 1877 a British commission considered a number of the sea foods and found evidences of an increased demand and a scanty supply. There were at that time imported into England from France "as many as" twenty thousand lobsters a year, while the whole Norwegian catch was "above half a million lobsters." The marked increase in cost was noted then as now.

A peculiar feature of the English argument was an objection to putting back into the sea the "berried hens," or females carrying eggs, for the reason that the eggs were considered more important than the lobster, since "when bruised they are much used in sauce." In 1877 the Irish and Scotch investigators recommended a minimum-size limit of eight inches—or four inches for the carapax or body shell—seven inches for Sussex lobsters, and for all a close season. These have been the changes upon which all subsequent laws have been rung to this day, and with them all there has persisted the decline in the catch of the lobster the world over.

In criticism of this policy—the establishment of a minimum length alone—it is to be argued that the perpetuation of any race must depend upon the adults of breeding age. This principle is unfortunately the very point that past and present lobster laws have failed to realize. The regulations have permitted and have

favored robbing the fishery of its best breeding stock. Permission to take all large lobsters, unless at the moment they are actually bearing eggs, founded as it was on faulty knowledge of the breeding habits of the creature, is now known to be a violation of biological principles. It takes from the race just the individuals most necessary to its continuance. And then with the legal limit at nine inches—it is eight in some parts of Canada—not one in fifty of the lobsters taken has ever laid an egg, while there can be little doubt but that in the interest of the canneries there has been a veritable slaughter of the innocents, although the "grasshopper-size" imputed to them at times has surely its measure of hyperbole. The catch has consumed the adolescent lobsters and the vigorous ones and there are plain reasons why in the case of this crustacean the policy has been most disastrous.

The reason is very obvious, the moment one considers the reproduction statistics of the lobster. The sexes are quite evenly divided. The female lays eggs and carries them about with her for eleven months before they hatch. The litters are biennial. The lobster is adult when between eight and ten inches long—the length varies somewhat—and the first litter is about five thousand eggs. The nine-inch lobster that is legally taken has not in general yet contributed to the perpetuation of the species. For its second litter, the lobster, then two years older and about eleven inches long, lays 10,000 eggs, the third litter is 20,000, the fourth, at about thirteen inches length, is 40,000 eggs, the next litter is again doubled to 80,000 eggs, while the lobster of fifteen or sixteen inches in length may be laying as many as one hundred thousand eggs. The chart makes the folly of present methods more evident in a moment than pages of description. The bottom figures are those of egg-carrying lobsters that were purchased by the State of Massachusetts in the year 1906-07. The length in inches is indicated and the number of lobsters in each group. The columns show relative egg-productiveness. No lobsters in these groups are protected unless they are actually carrying eggs. Dr. Field's suggestion is to protect the large, fertile individuals.

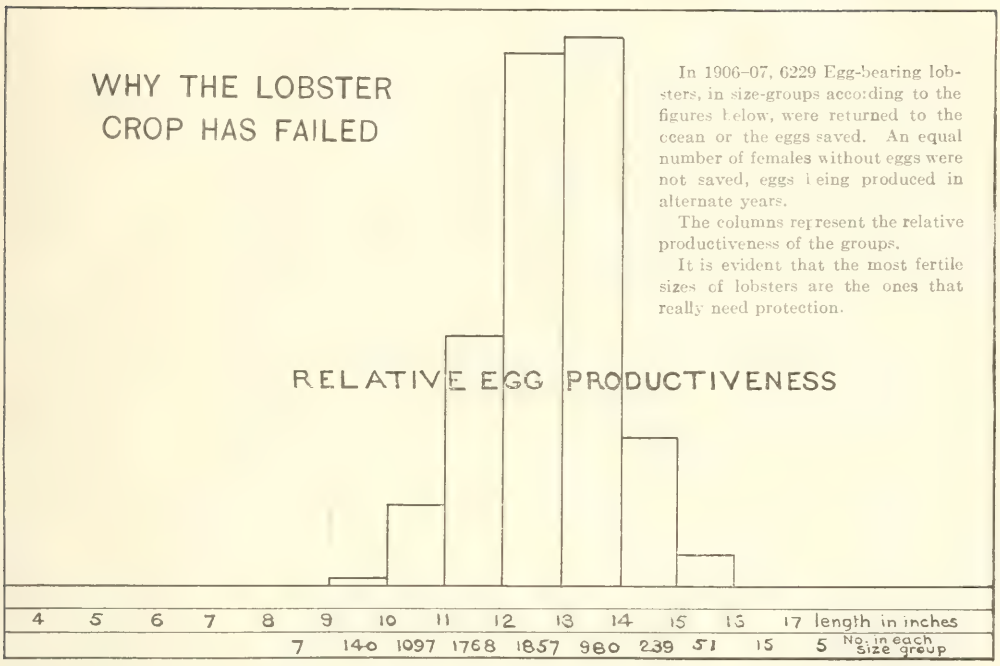
It is well worth while here to review the situation in New England, and that can best be done by noting from the Massachusetts reports what has been the value of the industry, and what has happened to it. Although Maine is a state with a greater total product of lobsters, the statistics and suggestions furnished by the reports of Dr. Field's office are convenient in form and direct to the point.

There are not wanting those who insist that the decline of the lobster is a fiction and that the catch today is as good as ever. To such men, and they are not infrequent or silent at legislative hearings, a single table from the commissioners' report of a year ago to the Legislature is refutation.

	Fishermen.	Traps.	Number of lobsters above 10½ inches	Egg-bearing lobsters	Av. catch per pot
1888	367	26,418	1,740,850	.....	81
1889	344	20,016	1,359,645	61,832	68
1890	379	19,554	1,612,129	70,909	82
1891	327	15,448	1,292,791	49,973	84
1892	312	14,064	1,107,764	37,230	79
1893	371	17,012	1,149,732	32,741	62
1894	425	20,303	1,096,834	34,897	54
1895	377	17,205	956,365	34,343	56
1896	453	22,041	995,396	30,470	45
1897	388	18,829	896,273	23,719	48
1898	340	16,195	720,413	19,931	44
1899	327	15,350	644,633	16,470	42
1900	309	14,086	646,499	15,638	46
1901	331	16,286	578,383	16,353	35
1902	410	20,058	670,245	.....	34
1903	309	20,121	665,466	.....	33
1904	326	19,539	552,290	13,950	28
1905	287	13,829	426,471	9,865	31
1907	379	21,342	1,039,886*	10,348	49
1908	349	19,294	1,035,123*	9,081	54
1909	522	29,996	1,326,219*	11,656	45
1910	390	26,760	935,356*	7,857	35
1911	341	19,773	822,107*	5,488	42
1912	284	16,545	636,203*	4,744	36

* Number of lobsters above nine inches, in these years the legal minimum length.

These statistics have been collected for the State for twenty years and more in conformity with the law. So long as the legal minimum limit in size was ten

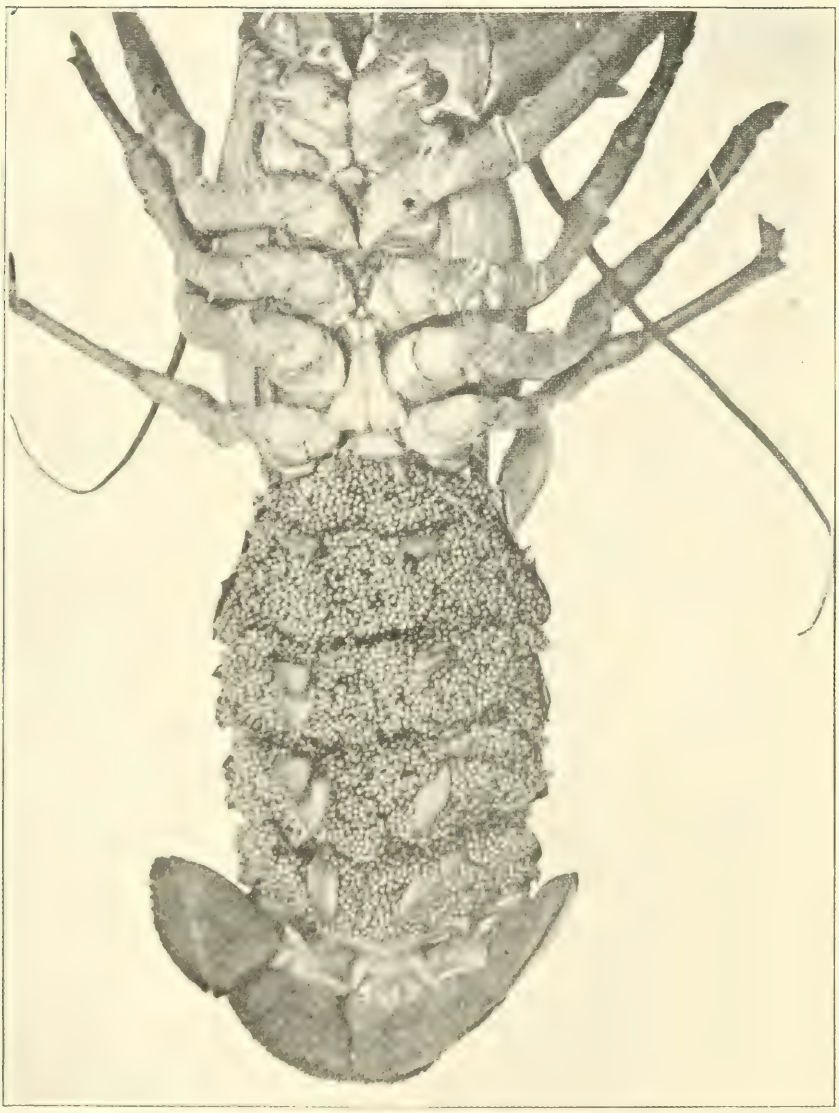

WHY THE LOBSTER CROP HAS FAILED
In 1906-07, 6229 Egg-bearing lobsters, in size-groups according to the figures below, were returned to the ocean or the eggs saved. An equal number of females without eggs were not saved, eggs being produced in alternate years.
The columns represent the relative productiveness of the groups.
It is evident that the most fertile sizes of lobsters are the ones that really need protection.
RELATIVE EGG PRODUCTIVENESS
4 5 6 7 8 9 10 11 12 13 14 15 16 17 length in inches
7 140 1097 1768 1857 980 239 51 15 5 No. in each size group

These are the lobsters that the Massachusetts law now protects ✕ These are the lobsters that may be legally taken if not egg-bearing

and one-half inches there was a steady decline, which was arrested for a brief time when the lowering of the limit permitted the larger catch, but this has not served to stop the decrease, merely to put it on another basis.

Taking for the starting point the year 1888, the catch stood at a million seven hundred and fifty thousand lobsters, a figure that has not since been equaled in Massachusetts. The number of men engaged in the business has fluctuated from the 367 of that year to 425, 453 and more recently even to above five hundred but still the catch has declined. The number of traps has remained substantially the same, with a few low years and very high figures for later years, and with this the area of the fishing has increased, but the catch has steadily declined, and with the fading away of the main fishery there comes the very serious element, that the number of lobsters taken with eggs attached to them has declined more rapidly than the fishery itself. In 1889 there was one lobster with eggs to every twenty-two in the entire catch and the decreases are these; by 1893, one in 35; by 1897, one in 38 and by 1904, only one in 42. At the end of fifteen years there were only half as many "berried females" in the catch.

In 1907, to counteract the evident decline in the catch, the size limit was lowered from ten and one-half to nine inches where it is today. The legislation was not in accord with the opinions of the scientists, but was in response to the demand of the men who saw their livelihood disappearing, and the outcome has proved it to have been a disastrous move. It is true that for a year or two the catch jumped up again, to above a million lobsters; it is true that two years later by dint of the unprecedented number of 522 fishermen, working nearly thirty thousand traps, and much new ground, the catch stood at 1,326,000, but now, two to four years later still the catch has come down again to about its old figures and the average per lobster pot is about the minimum. It is evident to him who cares to face the figures that the scarcity



How the Eggs are carried externally by the Female Lobster for ten to eleven months. Original by the R. I. Commission

of lobsters at above ten inches in length that was induced by the older regulations has merely been shifted and by continuing the same policy, the smaller ones are just as scarce now as were the larger ones six years ago.

It is when one scans the number of egg-bearing lobsters that a most important phase of the seriousness of the situation is very apparent. The ratio of such lobsters in the total catch was in 1889 one in 22 and under the ten and one-half-inch minimum it decreased gradually but persistently to one in 42 in 1905, and was exciting comment. But the first catch under the nine-inch law in Massachusetts showed this ratio to be one in 104, in three years it had gone down to one in 117 and in 1912 it was one in 135. These figures point clearly to an enormous decrease in the number of lobsters that bear the burden of the continuance of the species.

It is fair to ask here how much reliance is to be placed in such statistics of egg-carrying females, and what they really mean. It should be explained that the eggs of the lobster are cemented to the under side of the tail (see fig.), and are there carried by the female for ten or eleven months till hatched. It is a simple thing for the lobsterman in his boat to brush the creature with a whisk broom or with a mitten and make of it in a twinkling an ordinary, commercial lobster. This has been done a great deal in the past, and is impossible to regulate by any practical system of supervision. Massachusetts has cut the Gordian knot, and so have other states and Canada, by making the egg-carrying lobster a commercial article. The State will buy such lobsters from the fishermen for quite as high a price as the ordinary lobster will bring in the market. It is profitable to the lobsterman to hand such lobsters over to the State, and it is reasonable to assume that the number of lobsters bought by the State is practically the number of egg-bearing females actually caught. And it is an index of the ratio of such lobsters to the whole number. It, furthermore, gives a hint as to the number of females without eggs that may be taken in the non-egg-laying years.

Then there is another figure that is here important, which proves the lobsters to be getting smaller and smaller in the catches. Measurements made in 1905–06 showed that there were as many as 159 lobsters of more than twelve inches in length to every hundred under twelve inches, or three fifths of the whole, while in 1907–08 there were but 75 of the larger lobsters to every hundred smaller ones. The falling off here is almost one third.

It would seem as if there had here been assembled sufficient facts to convince any one that the lobster fishery in Massachusetts is truly in a precarious condition, and that if it is to be saved at all, it is high time to begin. And what is true of Massachusetts is true also of the other lobster-fishing New England states.

Let us look for a while at the world-over condition of the lobster fisheries.

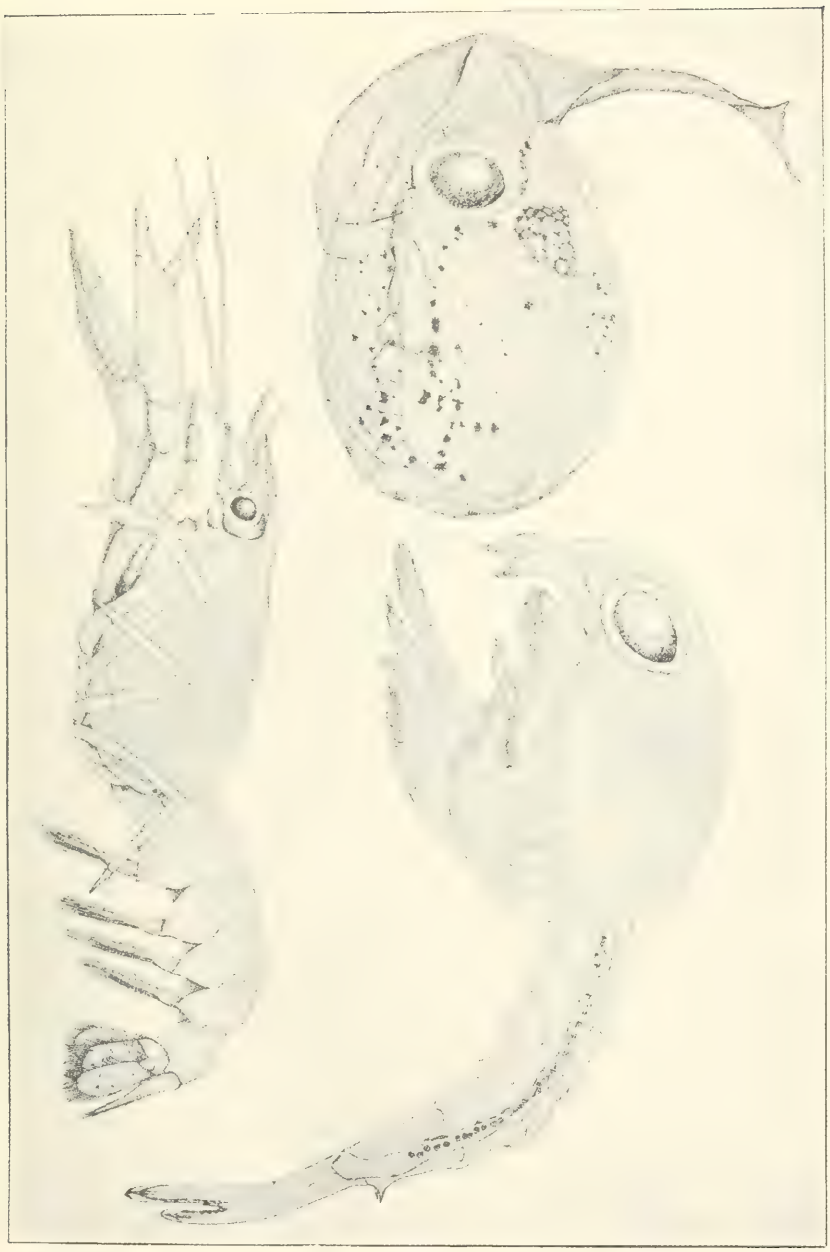
The Decapoda, in which order the lobsters are included, lie in three sub-orders, the long-tailed species like the shrimp and lobster; the hermit lobster and hermit crab, and the true crab. The lobster sub-order is again divided into five groups, the true lobsters, the fresh-water crayfishes, the shrimps and prawns, the spiny or rock lobsters and the warty lobsters. Crayfish, shrimps and prawns are widely distributed and edible. Some of them grow from four to six inches in length and it has seriously been suggested that they be brought from the Pacific Coast to supplement the failing lobster catch of the East. The spiny lobster, which lacks the great fore-claws of the common species, is well distributed through European waters and has always been esteemed for food. The edible portions are small in quantity but good in quality. In eastern America there are species attaining large size as far north as Bermuda; in California fourteen inches in length and three and one half pounds, weight has been reported, while Japan possesses a lobster of the same genus. Both the rock and the warty lobster are found in the Mediterranean; some of the spiny forms are distributed along the

coast of Africa to Cape Town, while in the antipodes, in New Zealand, there has been the taking of species of this genus with considerations of their propagation. No one of these sources of supply seems to be important in the world's consumption. The lobsters of the Antilles are now being caught for floating canneries, and it goes without saying that the supply will not last long; fully twenty years ago Rathbun called attention to the overfishing in California, and today the East hardly knows of the lobster of the west coast, while in Japan, the experiments in propagation seem not to have been successful. It is quite evident, therefore, that if the world is to continue to eat lobster as it is now doing, its dependence must lie in the true lobsters, and of these there are three known species, the American, the Norwegian and the common lobster of Europe.

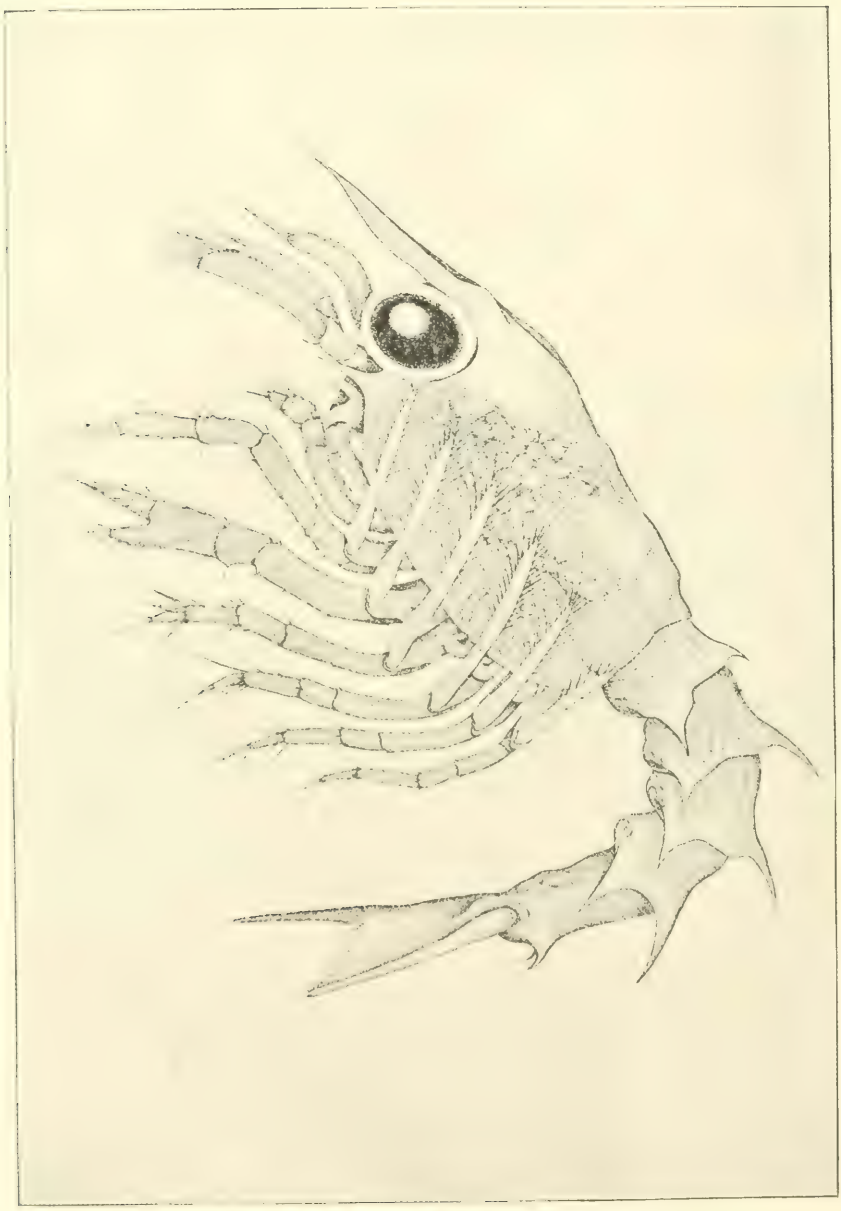
The American lobster and the European are practically the same, while the Norwegian crustacean is smaller and more highly colored. The catch of the latter is minor in view of the largeness of American measures; the process is by trawling in deep water and the catch is practically all males. If these conditions continue there is a reasonable amount of security to the fishery, for there is here no lobster-pot working day and night; there must always be a fair proportion of the males escape while the females are undisturbed in the important work of producing young. With the common lobster the case is very different and the female has been so seriously handicapped in her province that whether in Europe or in America the decline of the species is evident. The Norway lobster is an inhabitant of the coast of the country from which it takes its name, and is to be found plentifully along the shores of Ireland and Scotland, venturing sometimes into the Mediterranean. The common lobster of Europe extends from the north of Norway down the Atlantic coast and into the Mediterranean, including, of course, the British Isles. It is not found in Iceland; it does not go into the Baltic and its easternmost limit is the mouth of the Adriatic. The great fisheries are Norwegian. On this side of the ocean the lobster grounds extend from Long Island to the tip of Newfoundland at the Straits of Belle Isle, about ten degrees of latitude. In this country it is an industry of New England and Canada, and an industry of importance, for it has meant a million to a million and a half dollars a year to New England commerce, while in Canada the yield is three times as great. In Europe the Norwegian yield may touch two hundred thousand dollars; the French catch, which includes the spiny species, is about the same, while all Great Britain in its best days has surpassed the good years of Massachusetts only by about one third. This means that New England should be able by proper treaty and sensible home management to surpass in quantity the whole European fishery and hold for its own citizens a proper share of a profitable industry.

The lobster touches the pocket of the Massachusetts man, not only in the fact that his industry is passing away, but because he continues to eat lobster and the home supply means not more than 5 per cent. of the state consumption. The citizens are, therefore, expending a million dollars or so for what the general policy has suffered to be lost. The state has permitted an important food industry to slip away till it is now almost out of its grasp. And not only this, its own shortage in the supply has helped in the very large increase in the cost of the article. In a general way the lobster supply may be likened to the classic Sibylline books, and the total price for the remnant now equals the former worth of the whole. Massachusetts is paying to Canada its million or more for lobsters, and it is next only fair to inquire, "Where does Canada stand?"

Today the shores of Nova Scotia, Cape Breton, New Foundland and of the Province of Quebec in the Gulf of St. Lawrence, furnish lobsters to the world. In such a position of security Canada has been practically unhampered in its choice of policy, and, in addition, the mechanism of regulation of such a matter is far more simple than in the United



Upper Figure, Embryo escaping from Egg; Lower Right Figure, Immediately after leaving the Egg; Lower Left Figure, Young Lobster. Originals by Herrick



First Larval Stage. Original by Herrick

States. There was the possibility of a wise control, but it is patent now that the Provinces have but followed the same path as the other lobster-fishing nations, wherever they have existed.

It was not long ago, when the urgency of the situation was impressing itself on New England, that the Canadian policy might have been broadly translated as, "Have no fear, for we, by ourselves, can supply the world." The time has come when the shortage in the crop is imminent and Canada is itself considering the means for conserving its supply.

In the early seventies, when New England really first set about considering its problems, attention was directed in Canada to the general subject and in 1873 it was forbidden to take lobsters in the moult, females with eggs or short lobsters, the minimum being one and one-half pounds weight. The next year there was a close season established—July and August—and a length minimum of nine inches.

There were general variations in the close season; in 1889 the minimum length was increased to nine and one-half inches and after two years trial it was re-established at nine. Then there were experiments in the width between slats in the traps so that the little ones might crawl out, and these, with prohibitions and restrictions on trawling, lasted till 1894. In 1898 a commission was appointed to investigate and the result was the adoption in 1903 of the regulations substantially as they are now. These impose close seasons at different times in different localities with June to August for beginnings and December till May for endings; minimum lengths down to eight inches, different in different localities, the prohibition of capturing soft-shelled or "berried" lobsters, of selling broken meats, of boiling on board vessels, with various restrictions in the technique of catching, and the establishment of the lagoons of the Magdalen Islands for a close locality.

Regulations are comparatively easy to make and the proof of them is in the enforcement, so the Canadian officials have from time to time calmly considered the chances of proper compliance with them.

Now it is to be remembered that Canada is a country of canneries. In 1906 there were 700 such establishments with 12,000 employees, while $2,500,000 of the catch went to these and a scant million dollars to the live lobster industries. And here it is further to be understood that in the United States there is not one cannery, the last ones having been put out of business when in 1895 Maine increased the legal minimum to ten and one-half inches.

The Canadian authorities note that since the canneries are under inspection it is reasonable to believe that with their closing and the storing of the lobsterpots, the requirements of the close-season law may be fulfilled. The brushing of eggs from hen-lobsters is acknowledged to be a trying difficulty, since it would require an inspector or two to each boat to prevent the use of the whisk broom or the mitten. And as for short lobsters, the Canadian Department of Fisheries acknowledges that "it goes without saying that large quantities of lobsters under eight inches and, therefore, illegal, do find their way into the pack of the canners."

The Canadians have reasoned with themselves and in a report for 1908–09 one finds this statement: "The question, therefore, arises, as to whether regulations for the protection of the lobster fishery should be sufficiently drastic to seriously cripple or in many instances automatically close the factories with attendant effects upon the communities where they are operated?" One must make his own inferences as to the actual conditions that four years ago were the foundation for such a report, but it must be remembered at the same time that even so recently as this the symptoms of scarcity in the catch had not been seriously acknowledged in the Provinces. There was belief in existing plenty and a feeling that on account of wise legislation the fisheries of Canada had remained in good condition after forty years of use. According to the report of 1908–09 the Minister of the Marine and Fisheries sent his superintendent to give hearings in various of the coast cities, the outcome of which is the expression of opinion that

Fourth stage of young Lobster, when it assumes normal characters. At this stage it sinks to the bottom concealing itself daytimes. Original drawing by Herrick

Lobster Pots on Prince Edward Island, showing Rings of from Three and one-half to Four Inches. Courtesy of Mass. Commissioners

the canners cannot live if they are obliged "to render a strict observance of the legal size limit."

But there has been steadily coming in an undercurrent of conclusion that even these splendid fisheries are failing. The shortage of 1906 was ascribed to gales and bad weather but the official of the Quebec division says boldly, "It is useless to ignore the fact that in the Gulf division lobsters are becoming scarcer. This has been perfectly apparent for some years."

Today the Canadian authorities are realizing the true conditions, that the inexhaustible lobster supply is coming to its end. To view the new situation a new commission has been appointed, which is already at work. But what is there that can be done?

The lobster was maintaining its balance in nature, before man interfered, by laying from 600,000 to 1,000,000 eggs during its maturity. The lobster of today, in the vast majority, does not arrive at its first, tiny litter, let alone the enormously larger litters of later years. The present laws protect the young just so long as they are of no avail in maintaining the race. By legislation founded on mistaken knowledge of the story of the species, they are left from that moment and are the meat of any man who catches them. The policy of the future, if it is to be a successful policy, must reverse existing protection and care for the mature individuals, and the sooner the people realize this simple principle, the better the hope for the future.

Protection has been sought by a close season. The biological absurdity of this may be shown in a few words. A close season may be useful just to the extent that it stops the fishing. The catch in nine or ten months will probably be less than that for the twelve months. Then the demand is lessened when there are months in which such demand is illegal. But to have a real value the close season should correspond to the breeding time of the animal protected. Since the lobsters breed only every second year and

carry the eggs for eleven months, the question of what is not a closed season is a complicated one. Inasmuch as there is no correspondence between the close season and the breeding season, authorities have come to have little belief that it has any value whatever.

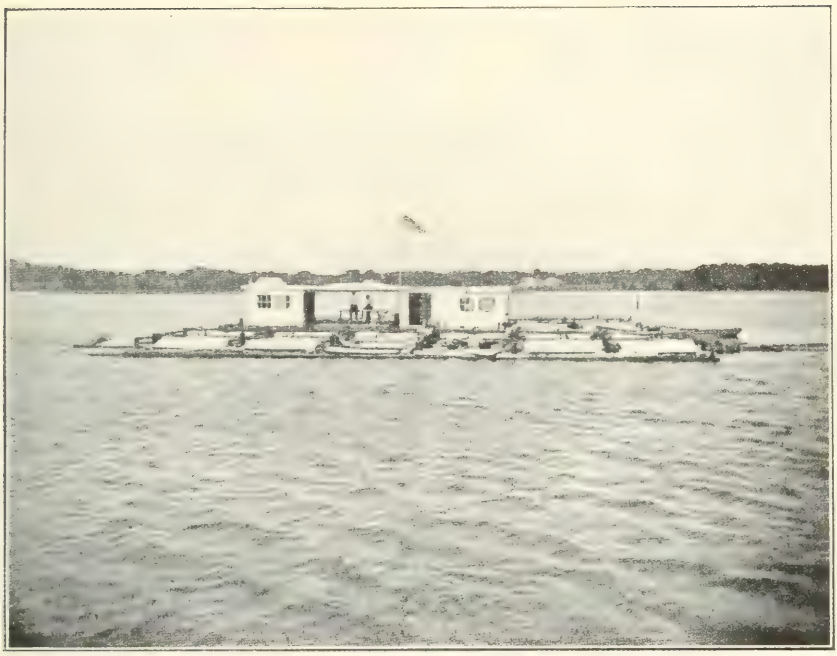
There is next to be considered the place of artificial propagation in the plan for restocking depleted waters, for it has been a plan upon which much has depended. It has had the consideration of the strongest scientific men, Herrick and Mead among them. It has, furthermore, been carried to complete scientific success in the hatcheries of Rhode Island and those of the United States Government, while Canada has hatched and turned into the water not less than 500,000,000 fry in a year, the totals for the duration of the experiments being in the billions.

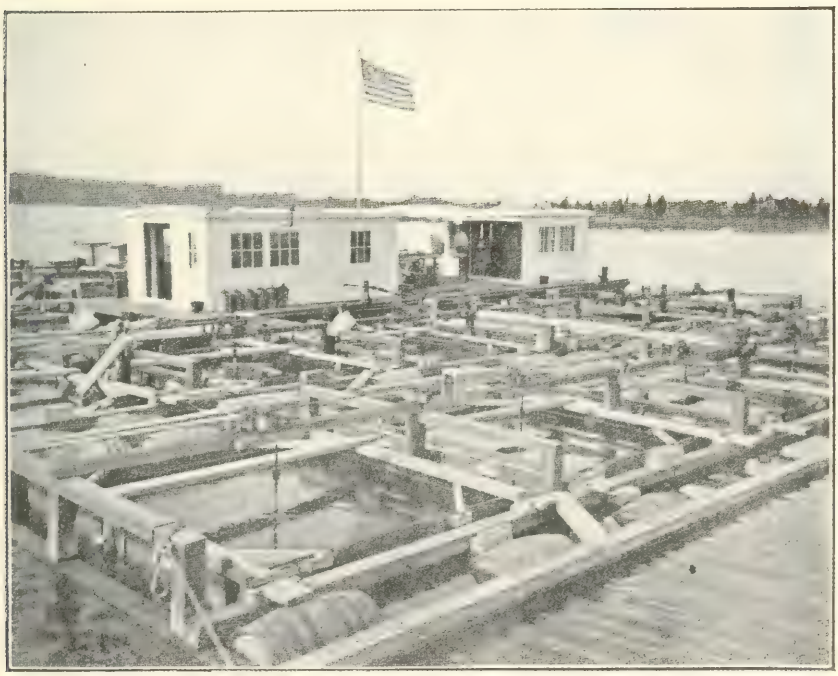
Under natural conditions the young lobster, once released from its neat packing in the egg, begins to show the characters that are prominent in the adult form. The great eye, the many legs and the jointed tail, are among these items. Belonging to the group of creatures encased in unyielding armor, Nature has made the provision here, as in the neighboring group, the insects, for a complete change of shell. When the lobster is too large for its outer case the case is cracked and falls off and a new one is made up from secretions of the surface of the body. Each time of moulting is a season of weakness, for without its hard crust the lobster is at the mercy of enemies.

During the first year of its life the lobster moults fourteen or fifteen times, but this rate is not long maintained and by the fourth year falls to every three or four months. When approaching full size there are few moults. During the first two weeks there are three moults, the real lobster form being taken on at the fourth one. The fry is then a strong swimmer and takes on the habit of going to the bottom, hiding among the rocks and burrowing in the sand. In its earlier stages the young lobster is the food of surface-feeding fishes and other lobsters, for these creatures are cannibals, and there is an enormous mortality; at the bottom it is much better protected. The two problems of artificial cultivation have been, therefore, to prevent cannibalism and to maintain the fry till past the fourth moult.

The extent to which Rhode Island has been interested in the hatching of lobsters may perhaps be most quickly judged by the accompanying illustrations. (Figs. see page 143.) The pictures illustrate the outfit at a distance and the houseboat and tanks in some detail. They present the developments by Dr. Mead, and have had the approval of scientific men. So far as Rhode Island is concerned, it is merely necessary here to say that Dr. Mead has been displaced, some alleging that the reasons were political. At all events it is reported that the Wickford hatchery is not at work this year and it is further true that in Massachusetts neither at Wood's Hole nor at Gloucester is there at present any Government work.

With this in view and the fact that all the great hatcheries in Canada are releasing only about 500,000,000 fry a year, the question comes in whether artificial propagation has not its economic limitations. Ten mature lobsters might produce a million eggs and care for them while five thousand such creatures—about the catch of "berried" lobsters in Massachusetts till today—would be doing naturally and without cost a work equal to that of the Canadian hatcheries. It is certainly very evident that man's efforts can be but puny when compared with the millions and billions of eggs that mature lobsters will easily produce if they can only be permitted their chance. On the one side there is the costly housing of the fry and the bringing up by hand, which is working at the wrong end of the lever, compared with proper protection of adult, race-perpetuating lobsters. And it is, furthermore, very doubtful whether the best efforts of man can keep up with the demand, for estimates by Herrick place the probable adults in ten years from all hatcheries at perhaps half a million, while in the same time from the same waters there would be taken from half a billion to one billion adults. Certainly a very unequal contest.





General and Nearer View of R. I. State Hatchery Houseboat and Tanks

Large Lobsters

Now there is here one interesting fact, that it has been practically proven that the large lobsters, if permitted to do so, will maintain their race. There is one little corner of the lobster shore, which shall be nameless here, where the supply has not been depleted and where large lobsters are still to be caught. The fishermen hold themselves strictly to conservative and scientific fishing, and woe be to the individual—friend or foe—who transgresses their rules.

The general facts exist, that wherever man has fished the lobster, the crustacean is becoming scarce. Legislation till now has utterly failed to arrest the depletion and artificial propagation has not been adequate to keep up the supply. What *is* to be done?

Of course there is one way, to fish lobsters just as they are now fished until they are commercially extinct. Then when they have no longer a money value they will be let alone; they will increase naturally, and a hundred years hence, they may again be a toothsome food for our descendants. The other way is to adopt sane and sensible measures for their conservation. The line has been marked out by Dr. Field and the scientific men support his suggestion. He has himself full confidence in its practicability, but it is no longer a matter where Massachusetts can act by itself. Four other New England states and New York must agree upon the same policy, or there would be instant competition. The matter was, however, presented to the governors of New England at the conference of 1908. At this time Dr. Herrick called attention to the grave errors of existing systems, which legalize the capture of the large, adult animals. Nothing, however, came of the conference in this regard. It is not a matter where the Federal Government has the right to interfere for here comes the prerogative of each state to arrange the business of its own citizens when within its limits. Then there is Canada in the competition, so that the question becomes an international one. There can, however, hardly be the doubt

about the awakening of the Provinces to the need of uniform and concerted legislation, and it is to be hoped, in that event, there can be concerted action of the New England states through the Federal authorities to meet the need.

And the needs are after all absurdly simple, a double limit protecting small lobsters at the one end, and at the other and above all the large adults of both sexes; protection of the "berried" lobster; the abolition of a close season and the adoption of a standard trap whose rings shall be so small as to exclude the large lobsters and whose slats shall permit the undersized ones to escape.

NOTE.—The illustrations are presented through the courtesy of the Massachusetts Commissioners of Fisheries and Game.

The reader who seeks detailed information in the matter is referred to Herrick's unapproachable volume, "Natural History of the American Lobster," in Bulletin of the U. S. Bureau of Fisheries, Vol. xxix, 1909, issued also as a separate in 1911 as Document 747.

VACCINES FOR WHOOPING COUGH

A VALUABLE paper on this subject from Dr. E. Mather Sill appeared in a recent number of *American Journal of Diseases of Children*. Dr. Sill states that:

"Thirty-three cases of whooping cough were treated with the pertussis vaccine, and in all the effect of the vaccine was to diminish markedly the number and severity of the paroxysms and the amount of vomiting.

"Absolutely no untoward effects from the use of the vaccine were noted. There were no complications in the cases in which the vaccine was used. No abscess formation, or even slight temporary inflammation or swelling at the site of the injection, and no general constitutional symptoms occurred. The longest time any of the children coughed was twelve weeks and four days. The longest time any child coughed after it was put under vaccine treatment was nine weeks and one day, the average length of time being four and one-half weeks. The injections were given every two or three days in most of the severe cases, and in the very severe cases every day for a few days, until the symptoms were relieved; the milder cases did not receive the vaccine so often nor so much at a time.

"The cases that were seen early in the attack, before the paroxysms had attained their height, seemed to respond more quickly to treatment and their course was shorter. In all cases, however, after one to three injections, the number and severity of the paroxysms was markedly lessened.

"Some children seemed to respond better to treatment than others, and I attribute this to the fact that the dosage was given irrespective of the age; therefore, the younger children got a larger dose proportionately, and as a rule these latter were the ones that responded most quickly to the vaccine and had the shortest attacks after treatment was begun. This fact is important, since (heretofore) these young babies are so apt to have pneumonia complicating or accompanying pertussis, with fatal results."

In connection with the use of vaccines for prophylactic purposes Dr. Sill makes the following comment:

"A very interesting fact is that prophylactic treatment was instituted by giving immunizing doses of pertussis vaccine to children in a family in which one of the children was under treatment for whooping-cough. These children were watched over a period of two months, and although they had never had whooping cough and were constantly exposed to the disease, did not contract it. It would seem, then, that the vaccine confers immunity to the child injected with small doses. One child of 5 years was given four injections of twenty million bacteria each, over a period of one month; another in the same family, 3 years of age, got nine injections of twenty million each, over a period of one month; neither child developed pertussis."

PROBLEMS OF THE INFINITELY LITTLE*

THE PROBLEM OF THE SIMPLEST MICROCOSM THE BASIS FOR THE SOLUTION OF ALL THE MYSTERIES OF THE UNIVERSE

BY R. B. BOWKER

THE twentieth century may achieve the solution of the problems of the infinitely little. It is these problems which bring the human mind to the confines of knowledge, to that borderland beyond which is the realm of the unknowable. In that realm the finite mind confronts what seem to it contradictions and impossibilities only, dilemmas of which it can grasp neither alternative, questions of beginning or no beginning, of end or no end, of bounded space or unbounded infinity, of limited time or timeless eternity, of tenuous matter or motionless void, which transcend not only time and space, but experience and thought. The spirit of science, the search for truth, cannot content itself short of the most thorough exploration of this borderland, in the hope, eternal in the human spirit, that it may even peer beyond the veil.

The problems of the infinitely little are also, in a sense, the problems of the infinitely great, of astronomy as well as of biology and chemistry. The nineteenth century learned that the macrocosm is an evolution from the microcosm. Moreover, our practical age has found that its inventions are of equal value for theoretical investigation and in the everyday service of man. The microscope, the photograph, the spectroscope, and the bolometer, extensions of our sense-organs, make the invisible visible, and register, in dimensions of micromillimeters, the penultimate facts alike of the cosmos, of life, of matter. Penultimate because beyond the sense-data which their revelations supply, scientific inquiry must proceed with the most delicate of all instruments of knowledge, the scientific use of the imagination. No man has seen or may see a molecule or an atom, yet we have come to know and to distinguish in their several kinds not only molecules and atoms but the corpuscles or ions from which they are built up. Hypotheses inductively developed from known facts are confirmed into laws and generalizations, from which are deductively developed new facts which form the starting-points for new hypotheses; and this "made ground" of human knowledge becomes as firm foundation, nay, firmer foundation, than the facts we seem to see, the course of the sun or the everlasting but everchanging hills.

Says Haeckel of one of his most daring conclusions regarding the chemical relations of bacteria: "I would particularly point out that this very justifiable statement is a pure hypothesis; it is an excellent illustration of the fact that we cannot get on in the explanation of the most important natural phenomena without hypotheses. We can see nothing whatever of the chemical, molecular structure of the plasm, even under the highest power of the microscope; it lies far below the limit of microscopic inspection. Nevertheless, no expert scientist has the slightest doubt of its existence, or that the complicated movements of the sensitive atoms and the molecules and groups of molecules they make up are the causes of the vast changes which these tiny organisms effect in the tissues of the human and the higher animal body."†

In astronomy, now the study of cosmic evolution, the final questions rest upon the physio-chemical cause of solar radia-

* Reprinted from *The City College Quarterly*

† "Wonders of Life," ch. Monera p. 203

tion, the elemental nature of comets and nebulæ, the possible existence within the solar system of star-dust that may condition the zodiacal light, and throughout space of infinitely tenuous matter that may even prove to be identical with the self-contradictory ether, the universal medium of radiant energy. It is the spectroscope which within the compass of the single octave of visible light, with its waves less than a millionth meter long, and the adjacent octaves, refracts the light from the farthest celestial sources into exact wave-lengths, certifies to us with exactness what chemical elements exist in these light-sources, discloses their physical condition, as solid or gaseous, and even from the shortening or lengthening of wave-lengths informs us whether a star is moving toward or from our system. From these spectrograph records the nineteenth century learned that the sun is a molten body with photosphere of gas, containing many but not all of the elements found on the earth, and no other, and that the stars are more distant suns, made up mostly if not altogether from elements known to us on the earth, but usually with fewer elements, varying especially in the different colored stars. Nebulæ, to the hundred thousand, whose light is so faint as to be undiscernible to the human eye through the largest telescope, nevertheless rearrange at a distance of millions on millions of miles the sensitive molecules of the photographic salts, and give us spectrograph records which prove their gaseous condition, though in the spiral stage of their evolution there may be discernible solid or viscous or liquid granules which are the evolutionary beginning of whirling worlds. When in 1901, for the first time since the development of these modern instruments of precision, a new star (Nova Persei) appeared in the heavens in the constellation Perseus—probably from a celestial collision between two dead and lightless stellar bodies such as we now infer to exist in great numbers throughout space—its spectrograph certified to us the existence of the same chemical elements which have been found alike in the earth, the sun and the stars, but with the distinction that a line produced by hydrogen was of extraordinary brilliancy. The spectrographs of the nebulæ show few and simple bands of light, that in Draco showing but three lines, of which only one is a hydrogen line. Here then in nature's elemental laboratory, we press to the very verge of beginnings and find not only that the substance of least atomic weight and presumably the simplest of elements plays the leading role, but possibly that the simplest "elements" are, as it were, in nascent or prenatal stage.

In physics, the knowledge of forces, the science of motion, the chief problems of today are in the study of those ether waves, through that wonderful gamut of 44 octaves which, beginning with the wave-lengths of Hertz vibrations, comparable in wave-lengths with those of sound in air, culminates in the actinic vibrations beyond the octave of light which have a frequency as high as 3,000 million million per second and a wave-length of .1 of a micron, the millionth of a meter. Sound, vibrating particles of air or other matter, is comparatively a gross force, though the mechanism of the human ear can distinguish wave-lengths so short as 8 mm. with a frequency of 40,000 per second. But the telephone has developed for us the translation and transmission of these waves and when Edison pricked his finger with the telephone point, there came the astounding discovery that the sound wave from an entire orchestra and a chorus of human voices, can be recorded in and reproduced from a resultant impression of a single line, whose characteristics are beyond microscopic test. While sound comes from motions of mass, so to speak, most of the other forces are comprehended as radiant energy in infinitesimal vibrations, known to us through their molecular, atomic or sub-atomic effects. Hotness and cold, with their similarly extreme effects on the human body—for frost also "burns"—the result of radiant energy in the octaves of heat, we now know to mean the increased or diminished activity of molecules adding to or taking from the molecular motion of

colder or hotter bodies, self-retained when surrounded by a wall of vacuum as in a thermos bottle. Below the heat octaves there are realms of the unknown into which Hertz and other investigators have been pushing their observations. Above is the octave of light and the half-explored realm of the actinic rays. All these investigations of modern science deal, it will be seen, with the infinitely little, each so called force in coördinate relation to which the analogies of sound have given us the key.

In physio-chemistry, the two sciences merge into each other in the borderland of the infinitely little, in the study of the once indivisible atom and its now ascertained corpuscular constituents. Since Prout in 1815 considered hydrogen to be the primal because the lightest element, that element had been nearly throughout the nineteenth century the basis and standard of all atomic systems, as those worked out by Newlands and Mendelieff in the middle of the century, and it seemed a sufficient marvel that two atoms of hydrogen constituting this molecule could be contained within the space of one 250,000,000,000th of an inch. But at the close of the century the wonders of radio-activity became known to us and the new element radium was found to have a complicated sub-atomic structure, from which corpuscles were emitted in continuous bombardment producing other elements and leaving a residual also unlike the parent substance. And within a decade, the imagination has come to the picture of atoms which are microcosmic planetary systems in which the constituent corpuscles revolve in orbits as the planets, in ordered array, producing in their interplay the wonderful series of vibrations recorded in the spectrographic lines through which the kinship of one element with another is disclosed. Myriads of these infinitely small bodies make up the tiniest atom and the whole universe of matter, and here again the infinitely little is the key to the infinitely great.

An extraordinary application of the methods of the infinitely little to practical purposes is found in the use of cadmium wave-lengths as shown in the spectroscope, to obtain an exact standard of measurement. When in 1790, in view of the uncertainty of the English yard and other "standards," the National Assembly of France provided for an exact standard of measurement which would be re-calculable and therefore never lost, the commission decided to adopt as the standard a ten-millionth part of the earth's quadrant which, as the standard from which all other measurements were to be deduced, it named the meter. No sooner had the measurement of the earth's quadrant been made and the sequent calculations completed and the new standard adopted, than it was found that an error of an appreciable fraction, making the meter 1/208th of an inch shorter than this ten-millionth, had crept in, so that the meter is not the exact standard it was intended to be and could not be exactly duplicated. The Bureau of Standards at Washington is now basing its work of exact measurements on the wave-lengths of the cadmium lines in the spectrum as determined by Michelson's interference method. Cadmium vapor is distinguished in the spectrum by three distinct lines which under given conditions are always of exactly the same frequency and wave-length, the red line of 310,678 vibrations per second, being peculiarly distinct and distinctive. The green line has a frequency of 393,307 and the blue line of 416,735, and these may be used for verification. By counting the number of red vibrations in a millimeter which is twice 1,212.37,* and multiplying and verifying the result, an exact standard for the meter is obtainable which can be remade should the physical standard be lost. Thus from the vibration of a particle of cadmium a result can be obtained which did not prove practicable by the older and larger methods of measuring the length of the pendulum or the quadrant of our earth.

In biology, the study comprehensive of all life on our earth, vegetable or animal, from man back to monera, from climax

* Michelson, "Light Waves and Their Uses," p. 95

to cell, the pressing problems are again those of the infinitely little. Whether we accept the dualistic philosophy of Kant, of spirit using matter as its instrument, or the monism of Haeckel, of matter evolving spirit, we confront alike the fact that sense-impressions are conveyed by infinitesimal changes through the sense-organs and nerves, recorded and associated in the infinitesimal phronema or thought-cells of the brain, and translated again through volition into action by means of infinitesimal changes in nerve-fiber and muscle. The modern inventions of the telephone, the phonograph and the photograph, furnish alike the proof of the transmission and recording of facts by infinitely small variations in physical conditions of the medium and the analogy for the modern view of the physiological method of psychic control. In the relations of psychology with physiology, therefore, the study of the cells which make up the tissues of the nerves, the brain, the muscles, must furnish basic facts. The very existence of the primate, man, in his individual body, is found to be absolutely dependent upon the most primitive structures, those monera or single and simple cell organisms on the borderland between vegetable and animal which we know as bacteria, for the study of which in defence of human life university professorships and extension laboratories have been endowed. A man housed in the body which houses his spirit is thought of in modern science as a United States, a physiological nation, of which the states, counties and towns are the members, organs and tissues, and the individual citizens are the countless myriads of cells, some life-building and others life-breaking, some indigenous to and others foreign immigrants into the body politic, the most of them good but some of them bad, all organized under a government of law and kept in due relation, each in its own function, by the well-ordering of the controlling spirit.

Modern biologists trace both the human embryo and the race history of our kind through successive forms to the gastræa, the "missing link" of primitive animal life hypothesized by Haeckel and later discovered by Monticelli.* This is simply a stomach sac, developed from a sphere made up from simple cylindrical cells, collapsed, so to speak, by the shrinkage of one hemisphere within the other, the inner layer or lining with a central orifice for a mouth differentiating into the nutritive tissue, while the outer layer or skin becomes the sense tissue of the organism, the intervening space constituting the primitive gut or stomach. The cells which make up this collapsed sphere were multiplied by cell cleavage from the single cell, the beginning of embryonic life, into which the parent cells united. The animal was long supposed to be distinguished from vegetal life by sensation, the power of motion, and the digesting stomach; but though in the higher vegetal forms, such as the sensitive plants, the sun-facing sun-flower and other heliotropic plants, and the insect-eating plants, these powers are limited, yet in the protist forms of vegetal life these functions are found to be closely akin to those in the protozoa or primitive animals. The bacteria, indeed, which seem to be unicellular animal organisms, though long classed by some scientists as vegetal, are linked in such gradation with the vegetal chromocea or unicellular plants that some forms are in a borderland between; and all these and other monera or single cell "organisms without organs," the simplest beings having "life," the most primitive forms lacking even a differentiation into nucleus and cell-body, are composed of the simple plasm of which all life-forms are built up.

In the nucleated cell, which is the beginning of life-differentiation, biologists are disposed to attribute heredity to the nucleus, and adaptation to environment to the cell-body or viscous jelly matter. Haeckel goes a step farther in attributing the psychic quality of memory to cells and pointing out that in the inorganic kingdom the crystal is kindred to the cell. The growth of crystals, he

* Haeckel's *The Wonders of Life*, p. 223

asserts, is "unintelligible without sensation," "as we could not otherwise understand the attraction of the homogeneous particles." Thus when a substance is in saturated solution the interposition of a single crystal of the same substance will instantly start the crystallization of the substance from out the solution, while the interposition of the crystal of another substance will have no effect. Biologic chemists, like Loeb, are now seeking to produce life-motions from inorganic combinations, and within the the range of an atom of carbon, an atom of nitrogen from the air, an atom of hydrogen from water, an atom of oxygen from either, and an atom of sulphur, nature indeed builds up a most striking succession of inorganic compounds that may give at least a key to the production of the living plasm.

It is noteworthy that the chromacea, so called from their color, which is mostly blue-green, and the chlorophyll, or green coloring matter of leaves, for the most part absorb and utilize the yellow, orange and red wave-lengths, of light, while Finsen has successfully applied the red light vibrations to the destruction of bacteria in certain diseases, an opposite or complementary effect full of suggestion to biologists. The most clear modern distinction between vegetal and animal life is that vegetal forms have the power of building up this plasm from inorganic matter, that is, are plasm-making, while the animal organisms must get their plasm through the vegetal factories and are plasm-eating. In this round of life, plants thus set oxygen free from carbon combination, while animals consume oxygen, combining it with carbon. But even this distinction seems to break down in some primitive forms. The final question of race history is whether when the earth cooled to a temperature making life possible, these inorganic chemical elements combined "at the psychological moment" into a life-cell from which by cleavage all succeeding life originated. Thus here again the study of life becomes a problem of the infinitely little.

This plasm is chemically composed of carbon, nitrogen, hydrogen, oxygen and sulphur, which five simple elements are the main factors throughout the range of organic life. Of these elements the albuminoids are altogether composed; and as albumin, the proteid which is the white of the egg and an everywhere-known form of this primitive plasm, is found to have a chemical formula $C_{72}H_{112}N_{18}O_{22}S$, a total of 225 atoms, it is probable that every particle of plasm contains hundreds of atoms, possibly in unstable equilibrium like the corpuscles of radium. The combination of these same elements in the inorganic world opens long vistas of analogies. Carbon, nature's most versatile element having six hands or bonds by which it can grasp other elements to itself—in its simplest form a black, odorless solid, absorbing and utilizing therefore light of all wave-lengths and when heated to incandescence returning all wave-lengths as white light—is the foundation in plasm of all animal and vegetal life. Nitrogen, the obstinate element, sensible neither to sight nor smell—which remains free in the air though in the presence of oxygen and because of its instability in combination forms the basis of all explosives—unites with carbon in the simplest possible union to form cyanogen (C N), a colorless, pungent, poisonous gas, burning in a pink flame edged with green. Hydrogen, also colorless and odorless, combines with cyanogen to produce hydrocyanic or prussic acid (HCN), a liquid, colorless but of almond odor, so volatile that it freezes from its own evaporation—a weak acid but the most deadly of poisons to all animal life. An atom of oxygen combining with this HCN produces cyanic acid (HCNO) or an atom of sulphur produces sulphocyanic acid (HCNS), one of the strongest of acids. Here then in the simplest sequence of combination of five of the simplest elements, is the beginning of marvellous permutations leading into the widest possible range of inorganic compounds in protein form—solid, liquid or gas; odorous or odorless; wholesome, inert or harmful; black or transparent; burning with white incandescence or variegated flame—ringing the changes indeed of all physical characteristics, the

greatest transformations produced by the simplest infinitesimal changes. But these combinations are also the beginning of organic life and accompany its fullest development, and within the range of these infinitesimal combinations a vast field of knowledge is yet to be explored.

Thus, alike in the cosmos, in the inorganic sciences and in the study of life, the problems of the infinitely little are our master-key to the final solutions. I venture a further thought toward the solution of perhaps the most vital problems of the physical life of man. Why should two or three harmless elements in combination rob the body of life? Why will light-vibrations of one wave-length produce agreeable or wholesome and those of another wave-length disagreeable or harmful effects? Why is the electric current at one potential harmless, at a higher potential deadly, at a still higher potential ineffective to the human body? Why is one man's meat another man's poison? It is plain that the vibrations which affect our senses change characteristically with each atomic change, and it seems possible that the tissues of each animal body, variable within a given range, are characteristically responsive in their cellular constituency to vibrations of certain character. In such correlation and in such responsiveness of structure and function to infinitesimal vibrations may some day be found the solution of the human mysteries of health and disease, of life and death.

I have not undertaken to speak of those problems of the infinitely little which, in the field of pure science, form the foundation of the magnificent structure of the higher mathematics, or of those others, which, in psychology, developed from the repetition of minute acts—in the moral nature as in the physical body—form habit and trend and character. I have confined myself chiefly within the range of that wonderful unity and continuity which in the physical world extends from the microcosm of chemistry through physics to the macrocosm of astronomy, in which dead matter is linked with or made into living organisms at points of contact in the field of the infinitely little which are still a mystery. It must be confessed that it is not even known that investigators like Loeb have done more than produce the semblance of life by electrical or mechanical self-excitation of inorganic combinations imitating living plasm.

In closing I can only refer to that new conception of the luminiferous ether foreshadowed in Mendelieff's "Chemical Conception of the Ether," and emphasized in Sir Oliver Lodge's very recent treatise on "The Ether of Space." This is the thought which I have myself endeavored to put forward; that the ether may not be different from matter but is literally the etherealization of that of which matter is the embodiment, whether, as in Kelvin's suggestion, matter rises from vortexes in the ether, or, as in Mendelieff's view, the ether may be the infinitely tenuous condition of chemical elements or of their final constituents, or, as in the theory of Thompson and Lodge, matter may be motions of the ether, from which not only a theory of matter but a theory of gravitation may be evolved. Sir Oliver Lodge goes so far in his commingling of psychology and physics as to suggest that here, in the ether pervading us and the universe, may be, in a fourth dimension of mathematics, that seat of the spiritual life which the authors of that remarkable book "The Unseen Universe" presaged. Thus the realms of spiritual mystery open to us in these vistas of the problems of the infinitely little. But indeed these be mysteries. Between matter and mind, between the dead and the live, so close to each other physically, there is still and may ever be the gap between the finite and the infinite—measureless. With all our science, we must still in modesty of spirit obey the words of the poet Robert Buchanan in the wonderful out-reachings of "The Book of Orm."

> "But still with those divine grave eyes
> Respect the realm of mysteries."

THE RELATION OF SNOW TO IRRIGATION AND FORESTRY

THE GREAT IMPORTANCE OF SNOW CONSERVATION AND THE METHODS USED FOR DETERMINING THE AMOUNT AND VALUE OF SNOWFALL

BY S. P. FERGUSSON

THE importance of accurate information concerning the amount and density of snowfall has been recognized only within recent years, and the application of methods of precision in experimental studies undertaken may be said to have begun within the past five years. At the present time the material gathered for study relates to but a few isolated places, and very probably, conclusions based upon these data will require modification when more complete information is available. The data employed in this paper were collected chiefly by Dr. J. E. Church, Jr., in what is probably the first systematic investigation of the relation of forests to snowfall and relate almost wholly to conditions in the Sierra Nevada Mountains in the vicinity of Lake Tahoe. It is believed, however, that some of the results, with a brief description of the methods employed in this work, will be of general interest.

In temperate latitudes an annual precipitation of about 500 mm. is considered sufficient for the needs of agriculture. This is the average amount occurring in a region comprising parts of Texas, Oklahoma, Kansas, Nebraska, and the Dakotas, central between the 93d and the 105th meridians. However, the variability of the rainfall in this region is so great that in times of extreme deficiency the natural rainfall must be supplemented by the methods of dry farming or by irrigation. East of this region the precipitation is abundant and seldom is so deficient as to cause partial failure of crops. To the west it decreases rapidly until in parts of the Central Basin, between the Rocky Mountains and the Sierra Nevadas, the average annual amount is less than 100 mm. Here, agriculture, horticulture, and forestry are almost wholly dependent upon irrigation, although in a few favored places dry farming has been moderately successful. The precipitation is extremely variable. In some instances nearly one-half the annual amount falls in two or three months, while the remainder of the year is relatively dry. Usually, the greater part occurs in the winter months, from November to April, in the form of snow, most of which falls on the western slopes of the high ranges, the amount increasing rapidly as the elevation increases. At the summit of the Sierras, at elevations of 2,500 to 3,500 metres, the annual depth of snow sometimes exceeds 15 metres and the amount on the ground at one time may exceed 10 metres. East of the summit, in valleys less than 40 kilometres distant, the annual amount may be less than one-tenth as much.

In the late spring the melting of the winter's accumulation of snow increases the flow of the streams to a maximum at the time the water is most needed for irrigation. In central and eastern Nevada this flood occurs in June while in the western part of the state it occurs in the latter part of May. The streams throughout the state are small and in some instances practically the entire average flow is utilized. To provide for future needs considerable attention is now being given to projects for the more efficient use of available sources of supply. Floods caused by sudden melting of snow during

"chinook" winds are, in many cases retained in reservoirs instead of being allowed to waste, and it is possible that overflows due to local storms or "cloudbursts" may be utilized in a similar way, although such storms usually occur too late in the season to be of much use in irrigation. It is not possible to increase or decrease precipitation by artificial means and there is no trustworthy evidence that there has been an appreciable increase or decrease within the historic period. Nor does the evidence support the popular belief that precipitation is influenced by forests or vegetation; it appears more probable that vegetation is a result rather than a cause of precipitation.

From recent studies it seems probable that vegetation may be of value in the control of stream-flow particularly where the streams are dependent upon melting snow. To what extent this may be possible cannot be predicted at the present time, but the data obtained so far indicate that an experiment is well worth trying. The study of the relation of forests to snowfall was undertaken by Dr. Church in 1908 as a part of the work of the Nevada Agricultural Experiment Station, the cost of the work being paid from the Adams Fund. Numerous measurements of the depth and density of snow in forests of different kinds and in open spaces at elevations between 1,500 and 3,000 metres have been made, also, studies of the variations of temperature in deep snow and the evaporation under differing conditions have been undertaken.

These data indicate, that, in the Sierra Nevadas and probably in other regions a larger quantity of snow accumulates in forests than on bare slopes and that there is an appreciable difference in the amount retained by different kinds of trees. Also, dense forests do not retain snow quite so well as those where groups of trees alternate with open spaces. In the accompanying table are compared the amounts of snow—at different dates—in three conditions of forestation. The figures are averages of about 65 observations each.

Date 1910	Treeless Meadow		Forest of Pine and Fir		Fir Forest	
	Depth of Snow	Water	Depth of Snow	Water	Depth of Snow	Water
	mm.	mm.	mm.	mm.	mm.	mm.
January 7	625	165	605	160	635	157
19	1056	249	1026	213	—	—
March 11	757	297	798	307	772	279
21	523	213	610	239	622	229
April 10–13	0	0	–	–	–	—
20	0	0	33	15	180	69

Dr. Church suggests as an explanation of the superiority of the fir forest that snow does not collect on the foliage in sufficient quantity or remain long enough to suffer loss by evaporation, which, on account of the active circulation of the air at the height of the trees, is greater than that from snow on the ground. This appears to be confirmed by measurements of evaporation conducted on the slopes of Mount Rose.

The sheltering effect of the forest is quite well shown in the accompanying photograph of the southern slope of Mount Rose. The two groups of trees in the foreground are at an elevation of 2,300 to 2,500 metres above sea level, and are about 700 metres below the summit. Very little snow accumulates in the western group, and the largest amount apparently is deposited in the open space between the two groups. Snow does not remain permanently on the bare slopes within 300 metres of the summit, but is blown toward the southeast and east sides where it accumulates in the forests. A belt of scrub 500 metres below the summit on the north side retains snow until it covers the tops of the bushes, but since these seldom exceed one metre in height, the amount retained is relatively small.

Under ordinary conditions the measurement of rainfall is not difficult and the instruments necessary are neither complex nor expensive. Practically the only serious errors encountered are those due to faulty exposure of the instruments. The determination of the depth and density of snowfall is much more difficult. If snow always occurred during calms, measurement would be easy, but, unfor-

South face of Mt. Rose, Nevada, showing the effect of trees on drifting snow

tunately, snow storms are usually accompanied by high winds which are so modified in direction and velocity by topography that gauge readings in any one place do not give accurately the average amount for the vicinity. Even in years of normal snowfall slight variations in the mean direction and velocity of the wind may cause an artificial excess or deficiency in some places, hence, to obtain a satisfactory normal for any particular region it is necessary to make a large number of measurements and determine the probable error of the mean of these.

The use of this method in surveying the watershed of a large stream, especially if the region is mountainous, usually calls for the expenditure of much labor and money. Instruments ordinarily satisfactory at sea level are entirely inadequate in the deep compact snows of mountainous districts, and with the development of interest in the subject has come the need of special devices for rapid work in the field. Of the snow gauges tried within recent years the simplest is a board upon which is painted a suitable scale. Readings of a large number of these gauges suitably distributed should give a close approximation to the mean depth of snow; but a second measurement is necessary in order to determine the water-content, which is the ultimate purpose of the work. Hence, a method whereby both elements can be determined from one measurement is to be preferred. In 1908, Professor Bigelow of the United States Weather Bureau, devised a snow-bin consisting of a wooden box measuring about 1.5 metres each way, placed high enough above ground to escape drifting snow. These bins, like all forms of "catch" gauges having vertical sides, did not catch the true amount of snow nor did they retain snow that had fallen in them when an increase of wind occurred after a storm. It does not appear that wooden louvres secured outside or inside these bins were very effective in increasing the amount caught. The only form of "catch" gauge that is approximately accurate is the one designed in 1886 by the late Professor Rotch of Blue Hill

Observatory. As shown in figure 1, it is a sheet metal reservoir of any desired size into which snow falls through an aperture the diameter of which is but one-half that of the tank. When fitted with a Nipher screen, shown in figure 2, this instrument is fairly accurate even in moderate winds. This screen, invented in 1878 by Professor Nipher of Washington University, is made of coarse wire cloth of about 3 mm. mesh which breaks up the eddies of air about the mouth of the instrument. Rain gauges fitted with this screen and exposed at considerable heights above ground have given practically the same readings as instruments on the ground, and experiments at Blue Hill indicate that screened gauges sometimes catch 50 per cent. more snow than those not provided with screens.

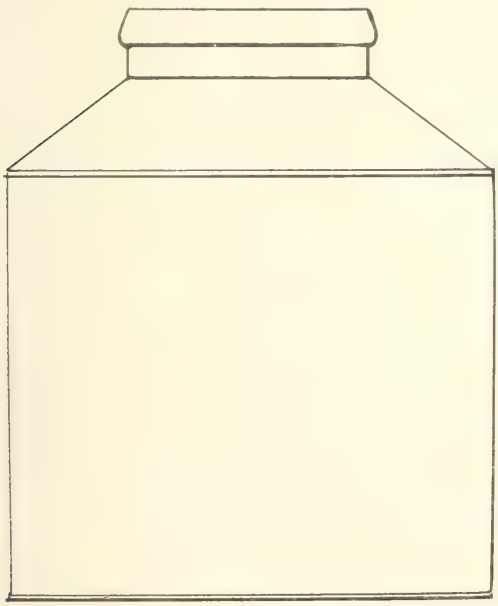


FIG. 1

On account of the cost and labor required to maintain instruments of the patterns described, it is probable that the well-known method of measurement by section is far more economical and efficient than any other in mountainous and sparsely settled regions. In its simplest form, as practised by observers of the Weather Bureau since 1885, this method consists of cutting a section by means of the overflow attachment of the standard rain gauge and determining the

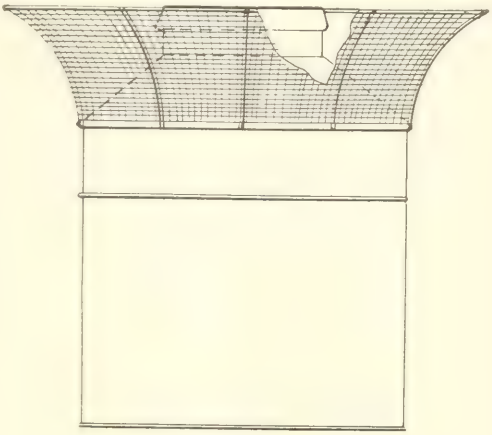


FIG. 2.

amount of water by melting and measuring it as rain. The writer does not know where precipitation was first measured by weighing, but weighing rain gauges were used in 1885 by Desmond FitzGerald at the Boston Water Works, and in 1886, the first weighing snow gauge was devised at Blue Hill Observatory.

In designing an instrument suitable for use in the heavy snows of the high Sierras Dr. Church first tried tubes made of sheet iron and fitted with steel cutters. These were entirely too weak and finally it became necessary to use seamless steel tubing. This material has proved to be amply strong although heavier than is desirable, and the instruments made from it, some of which have been employed in snow 6 metres deep, are very satisfactory. Details of the apparatus are shown in figures 3, 4, 5, 6, 7 and 8. The tube A may be of any convenient length, but usually where deep snow is to be measured it is made in two or more sections each 2 to 3 metres in length, which may be joined together as needed by means of screw couplings, B. Extending through the length of the tube is a

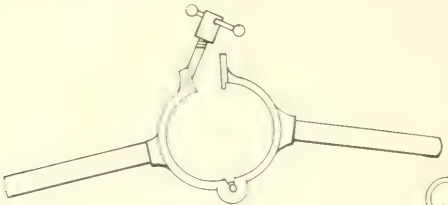


FIG. 5.

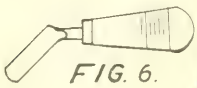
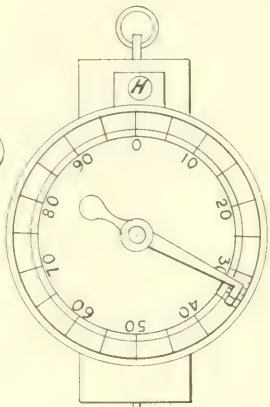


FIG. 6.



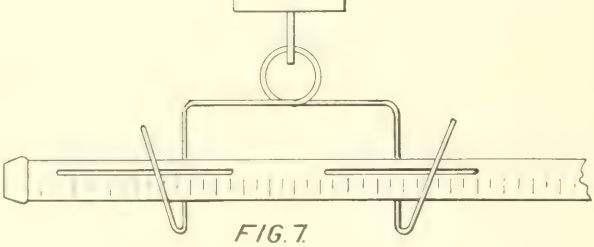


FIG. 7.

FIG. 3.

FIG. 4.

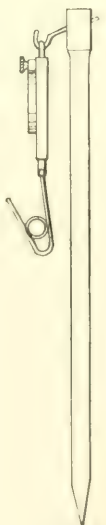


FIG. 8.

row of slots C, through which the length of the sample or core may be observed. The depth of the snow is indicated by a scale engraved upon the tube near the row of slots. The outside diameter of the tubes employed at present is $1\frac{3}{4}$ inches. The cutter D, which is soldered to the tube A, has an internal diameter of 1.5 inches for a space of about 3 mm. At E the diameter is increased about 2 mm., forming a narrow shoulder to prevent the sample from falling out when the instrument is withdrawn from a snow field. The sample is easily removed by inverting the tube, but any snow adhering may be dislodged by means of the tool shown in figure 6. The handle of this tool is also employed as a cylindrical gauge to detect any injury received by the cutter.

The water content of the sample is determined by weighting the tube and its core upon a spring scale, figure 7, the dial of which is ruled to indicate the depth of water instead of its weight. By means of a milled head H, the dial may be adjusted to read zero when the empty tube is supported by the scale, thereby simplifying the process of reading although there is no gain in accuracy. The index of the scale is a narrow strip of sheet metal with a line ruled upon its outer end so that estimates of fractional parts of inches or centimetres may be made with greater accuracy than is possible when the ordinary pointer is employed. The scale itself is a modified form of the well-known Forschner spring balance made of aluminum and weighing but two-fifths as much as the standard pattern. Usually it is accurate within about one or two tenths of one of the smallest divisions of the dial. For convenience in reading, the scale is hung on a staff, figure 8, which at other times may be used as an alpenstock or guide when traveling on skis.

A hinged wrench, figure 5, is sometimes necessary to drive the tube into deep compact snow. The weight of the entire equipment, including a sampler 6 metres in length, is about 12 kilograms and it can easily be carried by two men. Even in rough country several hundred measurements can be made in a day and a large region surveyed in a comparatively short time.

This instrument has been found satisfactory not only in the work of the Experiment Station, but also during a snow survey recently made for the Weather Bureau by Mr. H. S. Cole of the Reno Station.

As stated, the study of the relation of snow to irrigation is of comparatively recent origin and the results obtained up to the present time must be considered largely as indicating the methods to be followed in extending the research. The influence of forests of certain kinds upon the conservation of snow appears to be well established, from studies already made in natural forests. It is desirable now, to complete the work by planting new forests in favorable regions and measuring the effect upon neighboring streams.

COSTS OF CONCRETE BUILDINGS

Lockwood, Greene & Co., architects and engineers for industrial plants, Boston and Chicago, estimate the approximate unit costs of reinforced concrete buildings of various types as per the figures in the table below. These figures coming from a firm that has had such an extensive experience in this line are of more than usual value:

Type of Building	Dimensions	Live Load, pounds per sq. ft.	Cost above Foundation		Cost including foundation	
			Sq. Ft.	Cu. Ft.	Sq. Ft.	Cu. Ft.
Mch. Shop	120x50 4 sto.	150	$1.05	$0.08	$1.17	$0.09
Mch. Shop	220x100 1 sto. sawtooth skylights		1.65	0.09	1.75	0.10
Cartridge Factory	223x56 2 sto.	300	1.40	0.09	1.55	0.10
Cotton Mill	550x129 2 sto.	75	0.99	0.07	1.06	0.075
Weave Shed	341x231 1 sto. sawtooth skylights	125	1.66	0.064	1.79	0.07
Power Ho	90x62		2.53	0.115	2.67	0.12
Store Ho	181x56 4 sto.	150	1.08	0.065	1.15	0.07
Store Ho	256x100 12 sto.	150	0.90	0.09	0.98	0.105
Store Ho	223x56 2 sto.	300 and 1,000	1.20	0.08	1.35	0.09

Coal pockets above 3,000 ton capacity cost from $6.00 to $7.50 per ton. Reinforced concrete stand-pipes above the foundation cost from $2\frac{1}{2}$ to 3 cents per gallon.

SWIMMING POOL SANITATION

SOME PRECAUTIONARY METHODS THAT ARE NECESSARY TO KEEP THE WATER OF SWIMMING POOLS IN PROPER SANITARY CONDITION

BY JOHN F. NORTON

Although at this writing the season of indoor swimming is nearly over and that of outdoor approaching, still it seems worth while to look back a few months in order to get, if possible, a few lessons which may be of some interest when we again put on the scanty bathing suit of the indoor pool and refresh ourselves at the public swimming tank or Y. M. C. A. after a hard day's labor. Besides, a good deal that can be said concerning the sanitation of the indoor tank could, with good results, be applied to outdoor swimming, particularly to some of the municipal bathing houses which are too often located near badly polluted harbors or rivers.

That swimming or bathing, whether outdoors or indoors, in water which is highly contaminated with human waste may be a means of spreading disease, is beyond question. First, there are certain intestinal troubles, such as typhoid fever, which may be contracted by swallowing polluted water. It must be admitted that the chances here are much less than with drinking-water owing to the smaller amount generally consumed, but these diseases have been at various times traced to bathing, and no one seems to be ready to state in definite terms what the allowable chances are as compared to drinking-water. For this latter purpose the standard usually taken is that if one or more bacteria belonging to sewage types, such as the colon bacillus, are found in one cubic centimeter (about 15 drops), the water is not safe to drink. It seems a little hard to judge water for bathing by this standard, but at present it is the only one we have.

Besides internal diseases there are certain infections of the skin and external mucous surfaces which may arise from swimming in contaminated water. The organisms causing these troubles get into the water from the bodies of other bathers. To prevent the spread of such diseases it is essential to prohibit the use of pools to known infected persons, to insist that everyone should be clean before entering the tank, and to make sure that all bathing suits are properly boiled after each use.

The ideal way to conduct a swimming pool would be to completely empty the tank, clean and refill it each day, but it is seldom possible to do this. In the first place the time required would make the pool much less useful than it should be, and, secondly, in many places the cost of water would make such a procedure prohibitive. It has, therefore, become quite general to install some sort of a purifying system intended to keep the tank in good condition.

Such system should comprise, first, an efficient means of cleaning the bottom and sides of the tank each day. This is done in some places by means of a brush or a piece of hose serving as a brush. A very good method, which recently came under the observation of the writer, consisted of an arrangement very similar to a vacuum cleaner by which the dirt and hair clinging to the tank was sucked out. This proved very efficient and easy to operate.

Second, there should be some way of keeping the water in good physical condition, that is clear and colorless. Generally the water is withdrawn from the

tank, passed through some sort of a filter and then returned for use. The arrangement is such that this is a continuous process, only a small part of the water being withdrawn at a time. The type of filter used varies considerably. Sometimes it consists of a bed of sand over which the water is sprayed, a method comparable to that used for sewage treatment. The suspended matter is retained by the sand and unstable organic matter is rendered stable. The more common types are, however, such as are used in water purification. These consist of one or more large drums filled with broken stone or cinders. Alum is added to the water just before it enters the filter. The alkali in the water causes a gelatinous precipitate of aluminum hydroxide to form which collects the suspended and coloring matter, and is caught in the stones as the water passes through the drum. The slimy deposit in the filter prevents the passage of very small particles, even bacteria being retained to the extent of about 80 per cent. If the operation is properly carried on, no alum should pass into the tank, where it would cause the water to become cloudy, but if some did get through no other trouble would follow, as alum, at least in the quantities liable to be used, is a perfectly harmless substance. The number of bacteria removed is not sufficient so that we can depend on this method for the entire purification.

Third, an indoor swimming pool is an excellent incubator for micro-organisms, as the temperature, usually about 70 °F., is favorable and enough food is supplied from the bodies of the bathers. Some further system must, therefore, be used in order to remove any dangerous organisms, and so prevent the spread of disease. The most efficient, cheapest and easiest thing to use is calcium hypochlorite,—the ordinary chloride of lime. This, even in small amounts, is a good germicide and is harmless to anyone using the water. To add it to the water it is necessary only to warp about a pound for each 50,000 gallons of water, in a piece of cheese cloth, tie it to the end of a pole, and draw it around the tank. The water will dissolve the chloride and the cheese cloth will hold back any large particles of foreign matter. It is best to do this the last thing at night so that there will be plenty of time for the disinfectant to act before the pool is again used and also so that the odor of the chloride will have entirely disappeared.

Another reason for allowing the tank to remain quiet for some hours is that large numbers of the bacteria will settle along with the dirt and other suspended matter, and will thus be removed in the morning when the tank is cleaned. In the opinion of the writer this sedimentation is one of the most important factors in keeping a pool bacterially clean, and will be, even in the absence of other methods of purification, a considerable safeguard against disease. It should be noted that the cleaning must be done regularly and efficiently and without stirring up the contents of the tank.

During the past winter the writer has had an opportunity to watch a swimming pool in which systems of cleaning, purifying and disinfecting, as above described, have been used simultaneously. The same water was used for a number of weeks, only enough fresh water being added each day to replace that lost by splashing and cleaning. This amounted to about one eleventh of the capacity of the tank. The filter was kept in operation during the daytime and was of such a capacity that the whole contents of the tank were filtered each day. At night chloride of lime was added, and in the morning the sides and bottom of the tank were cleaned by suction. Chemical and bacteriological examinations were made at intervals in order to study the extent of pollution of the water.

The actual figures obtained will not be given as many of them had no particular meaning, but certain conclusions were drawn from some of them. The first was that it is possible by efficient cleaning and filtration, to keep an indoor pool in excellent physical condition for an indefinite length of time. Second, that a disinfectant must be added in order to sufficiently remove the bacteria. Third, that this disinfectant is not troublesome

THE SOCIETY OF ARTS OF THE MASSACHUSETTS INSTITUTE OF TECHNOLOGY

The Society of Arts was established as a department of the Institute by President Rogers in 1861. It is especially devoted to the general dissemination of scientific knowledge, and it aims to awaken and maintain an interest in the recent advances and practical application of the sciences.

Any person interested in the aims of the Society is eligible to membership.

The annual dues are $3.

RICHARD C. MACLAURIN, President of the Institute.
ISAAC W. LITCHFIELD, Secretary of the Society of Arts.

EXECUTIVE COMMITTEE

THE PRESIDENT
ELIHU THOMSON
JAMES P. MUNROE
THEODORE N. VAIL
ARTHUR D. LITTLE
FREDERIC H. FAY

THE SECRETARY

BOARD OF PUBLICATION

D. F. COMSTOCK
SELSKAR M. GUNN
ELLWOOD B. SPEAR
LEWIS E. MOORE

I. W. LITCHFIELD, Editor

Science Conspectus is published December, January, February, March and April.

to the swimmers, as no complaint was ever received from them. Fourth, that even with the addition of a disinfectant the number of bacteria will become excessive after a time—in the case of this particular pool about one month. The time would probably be greater or less, depending on the size of the tank and the number of people using it. Indications were that the increase of bacteria was due to the gradual development of a resistance to the disinfectant by one species of organism.

In conclusion it can be said that while the indoor swimming pool may become a source of danger, yet it is perfectly possible, by using the proper precautions to keep it clean, to reduce this danger to very nearly nothing. It will require some care and trouble and a little expense, but isn't it worth while?

WAGES IN VARIOUS COUNTRIES

From the results of thorough investigations undertaken by the Board of Trade, England, relating to the wages paid to workmen in England, Germany, France, Belgium and the United States, some interesting data on the comparative wages in these countries may be obtained. These data present a fair average, as not less than ninety-four industrial centers in Great Britain, thirty-three in Germany, thirty in France, fifteen in Belgium and twenty-eight in the United States furnish the basis for the comparison. As a general average it may be stated that the wages of American workmen are 50 per cent. higher than those of English workmen. In the European countries wages are highest in England and lowest in Belgium. English workmen are, in general, paid 25 per cent. more than German workmen, and 36 per cent. more than workmen in France. Relating to wages in the metal industries, the following figures will be of interest: Lathe hands are paid in London $9.50 per week of fifty-four hours; in Berlin, from $9.10 to $9.45 per week of from fifty-seven to sixty hours; in Sheffield, $9.25; in Düsseldorf, from $8.00 to $8.75; and in Antwerp, $5.85, for sixty hours a week. Of European countries, England shows not only the highest wages paid but also the shortest working hours. Belgium with the lowest wages has also the longest working hours. The investigation also covers the cost of living in the different countries. Thus, for example, rents for similar accommodations are nearly twice as high in England as in Belgium, and about twice as high in the United States as in England. The average prices of food products as compared with the English prices are 17 per cent. higher in Germany; 18 per cent. higher in France; 1 per cent. lower in Belgium; and 28 per cent. higher in the United States.